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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

PRIMITIVE PLANT BREEDING IN THE CAUCASUS

(See Page 3)

Inheritance of Bone Deformities

A Guide Book to Heredity

Mutations in Apricots

JANUARY, 1928 Vol. 19, No. 1

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Photograph by M. G. Tzupa

ARGEN EGYARAROV—PLANT BREEDER OF THE CAUCASUS

Frontispiece

Between the Caucasus Mountains and Mt. Ararat, in the village of Kassapet, Argen Egyararov carries on selection of durum wheat according to principles that his forefathers have learned through generations of observation. The result is that in this community the seed wheat is of an excellence that would do credit to a seed farm with all modern facilities.

AT THE SOURCES OF PLANT BREEDING

N. N. KULESHOV

Institut de Botanique Appliquée, Kharkov, U. S. S. R.

Photograph by M. G. Tzupa

A SAMPLE OF THE SEED

Figure 1

Some of the seed wheat selected by Argen Egyararov. Unfortunately the photograph does not reproduce the beautiful amber color of these grains of "Zaerda."

IN the southeastern corner of the Isthmus of the Caucasus is situated the Republic of Azerbaijan making part of U. S. S. R. The republic is limited on the East by the Caspian Sea, on the North tower the mighty Caucasus mountains, on the South, along the rivers Arax and Astara, it borders on Turkey and Persia, and to the West its boundary is formed by Armenia and Georgia.

The whole area if the republic occupies about 80,000 square kilometres, of which 900,000 hectares (2,223,000 acres) are under the cultivation of different field, vegetable and garden crops.

In spite of its small territory Azerbaijan shows a great diversity of natural-historical conditions and its situation on the "Highway of Nations" from Asia to Europe, the great Indian road, has left deep traces on the national aspect and on the way of life of the country.

As regards the technic of agriculture the population of Azerbaijan is still on a very low level. The principal implement for tilling the soil is a wooden plough with a metallic head, called "kysh" or "jute"; a harrow, as we understand it, is completely, unknown; the principal and almost sole method of harvesting cereals is cutting them down with a sickle; the winnow is a very rare farming implement. Up to now a considerable part of the population lead a semi-agricultural, semi-nomadic life. Nevertheless the agricultural possibilities of the country are very great and a whole series of valuable crops may be raised: cotton, rice, etc.

The country is not now very intensively tilled; the fields of Azerbaijan might be considerably increased in acreage with a consequently greater total production.

In the summer of 1926 I was charged by the Institute of Applied Botany

with the direction of an expedition whose purpose was to study the cultivated plants of this most interesting country.

Exchanging the saddle horse for the motor car, and the motor car for the cart drawn by buffaloes, ascending from the Caspian lowlands to the heights of the Shakh-Dag, the expedition traversed in the course of three months about 6000 kilometres of country roads, collecting seed samples, ears and herbarium material. Most attention was involuntarily devoted to wheat, occupying in Azerbaijan about 55 per cent of the total acreage under cultivation. As regards their species and varieties the wheats of Azerbaijan represent an extreme diversity. The following wheat species were met with in cultivation:

1. *Triticum vulgare* Will.
2. *Triticum durum* Desf.
3. *Triticum turgidum* L.
4. *Triticum compactum* Host.
5. *Triticum pyramidale* Perciv.
6. *Triticum polonicum* L.
7. *Triticum persicum* Vav.
8. *Triticum dicoccum* Schrank.
9. *Triticum monococcum* L.

In numerous cases the expedition encountered fields sown with a mixture of *T. vulgare, T. turgidum* and *T. pyramidale;* other combinations also presented themselves.

Along with fields, showing a mixture of species, others were met with, sown only with one species, but displaying a great diversity of the varieties composing them.

Not infrequently on one square meter five, eight, even ten varieties could be identified, though of course there also occurred fields comparatively uniform in regard to their specific and varietal composition.

The Plant Breeders of Karabakh

In the itinerary of the expedition was included the autonomic territory of Mountainous Karabakh with a prevailing Armenian population. We entered it from the southwest, having passed over the mountain chains Zangezur and Karabakh.

Photograph by M. G. Tzupa

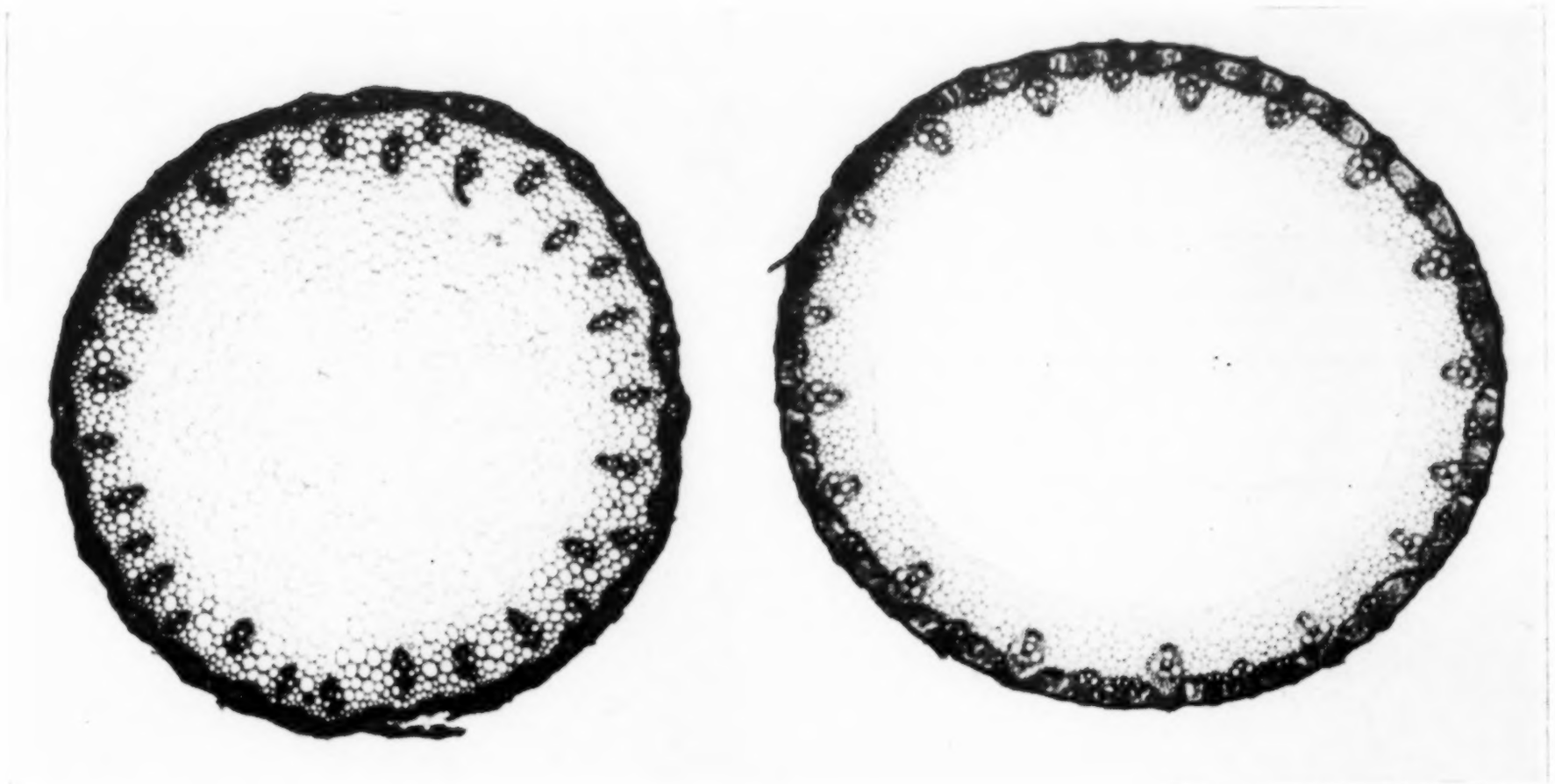
A HEAD OF "ZAERDA"

Figure 2

Typical of the durum wheat raised in the village of Kassapet. Only the seed from the central part of the head is used for seed.

In our preceding work we had become accustomed to the extreme diversity of wheat fields, and we were greatly astounded, therefore, when in the barns of the settlements Tchertaz, Suz, Kassapet we met with great stacks consisting of sheaves of *Triticum durum* and showing such purity of type that a seed growing farm would not have been ashamed of such stock.

In connection with the extremely primitive methods of cultivation, this fact was especially astonishing. Inquiring closer into it we were able to establish that we had met with mass



Photograph by M. G. Tzupa

CROSS SECTIONS OF STRAW

Figure 3

The durum wheat of Azerbaijan has two types of straw,—hollow straw like most of the ordinary varieties, and straw which is entirely filled with pith (at left). Only the seed of plants having entirely solid straw is used for seed by the plant breeders of Kassapet. It is yet to be learned whether this character has any value in increasing the strength of the straw and thus preventing lodging, or whether it protects the plant from insect pests.

selection work carried on in these settlements.

Cut off from the railway by hundreds of versts of descent and ascent, by forests, and deserts, the farmers of these settlements have heard nothing of experiment stations or plant breeding; and yet through whole series of generations they have been carrying on a systematic and strict selection of *durum* wheat. Not all inhabitants of a settlement are engaged in this occupation, but the selection is carried on by certain individuals who have learned the methods from their fathers as these inherited them from the grandfathers, so they are, in their way, "hereditary plant breeders."

The existence of such selection work in some of the settlements of Azerbaijan has been already mentioned in Russian literature by L. L. Dekaprelevitch, still we were deeply impressed when we chanced upon the fact, and on such a large scale.

A membeer of the expedition, M. G. Tzupa, has taken a series of very interesting photographs illustrating the work carried on by the plant breeders of the above-mentioned settlements, and which I take the liberty of reproducing in this place.

The Frontispiece represents the "plant breeder," Argen Egyararov, inhabitant of Kassapet. In his hands rests the final sorting of the selected material and he choses the seed destined for sowing purposes.

The preliminary selection work is performed by all the members of his family. Figure 4 shows the "laborants" at work.

The qualities required from the plants selected for reproduction may be summed us as follows:

1. The plant must have a well developed typical ear, characteristic of the selected material;

2. It must have straw filled with pith through its whole length, from ear to root.

3. The seeds intended for sowing are taken only from the middle part of the ear. The upper and lower part

Photograph by M. G. Tzupa

THE EGYARAROV FAMILY AT WORK

Figure 4

Only one family in the town of Kassapet are plant breeders, and they have been engaged in the selection of the seed wheat for generations. All the members of the family take part in the work and perform the preliminary selections, but with the head of the family rests the final decision as to which heads of grain shall actually be used for seed.

Photograph by M. G. Tzupa

LARGE UNIFORM HEADS OF "ZAERDA"

Figure 5

"Zaerda" is the local name for wheat, descriptive prefixes being used for the different varieties. A definite system of naming the selections is also employed, the name of the variety and the year of selection being known.

are removed and not used for sowing purposes.

Let us dwell with more detail on these requirements. Among the varieties of durum wheat used for selection the following ones are met with:

T. d. hordeiforme
T. d. apulicum
T. d. murciense.

All these wheats are known under the name of "zaerda" with the addition of a prefix characterising the color of the ear or of the grain.

Figures 2 and 5 show a single ear as well as a bunch of the selection material. In Figure 1 the grain of the selection sort is represented.

The photographs illustrate sufficiently well the external properties of the select "zaerda." Unfortunately they are not able to reproduce the beautiful ambre color by which the fine, big, uniform grain is characterized. We were not able to ascertain with sufficient clearness the reasons why in selection preference is given to plants with solid straw and why plants showing normal hollow straw are eliminated. But the fact itself of the occurrence in great masses of this peculiar straw filled up in all its length has been frequently observed by us and our collections contain a considerable number of such plants.

Figure 3 shows the cross sections of the stem of two fully mature wheat plants grown in the same plot and belonging to *T. d. hordciforme*. One of these plants with hollow straw was eliminated, the other showing solid straw was selected for reproduction.

In both cases the cross-section was made through the seond internode from the base.

Even in a cursory survey of Figure 3 the difference in the structure of the straw of the two abovementioned plants stands out clearly. This difference refers not only to the fact that in one case we have a perfectly hollow straw, in the other one filled up with pith, but shows itself also in the structure of the mechanical tissue, the number and arrangement of the fibrovascular bundles.

It would be of great interest to investigate this solid straw from the point of view of its ability to withstand lodging. Very interesting also is this quality from the entomological point of view.

As already mentioned before, the seed intended for sowing purposes is taken only from the middle part of the selected ears. As the middle part of the head usually shows the largest and most developed grains, the removal of the upper and lower parts replaces to a certain degree the work of grading machines by means of which grain of uniform size and development is obtained.

In the settlement of Suz we met with another "plant-breeder," Alexander Bagdassarov, who was carrying on selection work with *Tr. turgidum.*

In this case selection was conducted according to a less complex scheme and consisted in singling out the well developeed ears typical of the selected variety.

The records taken by M. G. Tzuba show that the selection work in all above named settlements bears a systematic character and is carried on from year to year.

In one year A. Bagdassarov, according to his own words, obtains by way of selection 10-15 kilos of excellent grain. Next year this "elite stock" is reproduced, the yield running already into puds. The grain obtained from this reproduction is also preserved for next year's sowing, after which the return is already destined for alimentary purposes and all carried to the mill. Thus, on the fields of these "plant-breeders" we have the sowing of "Elite Stock Seed," the sowing of the first reproduction, and the return of the second reproduction, which is already intended for food.

A perfectly harmonious and expedient system! When inquiring about

the name of a variety on one of the field plots near the settlements, one may hear the answer: "Sowing of Zaerda, 1922." Not only the name of the variety but also the year of selection is mentioned.

From the point of view of modern plant breeding there may be many faulty and naive features in the selection work described above; but here we have to deal, in the majority of cases, with illiterate people, who have hardly ever gone beyond the boundaries of Mountainous Karabakh.

Let there be errors; let there be much waste of time; but even if the adopted method of selection should be erroneous, still we must acknowledge the fact that, in this instance, we have to do with plant breeding, though primitive, but carried on deliberately since ancient times and having given rise to scientific plant breeding.

We must lay particular stress on this fact, as the way itself in which many forms and varieties of cultivated plants have originated has up to now remained unexplained.

Report of Plant Sterility Conference

THE Conference reported in this volume* is the third of a series held under the auspices of the Horticultural Society of New York. The former conferences were on "Plant Breeding and Hybridization" in 1902 and "Plant Hardiness and Acclimatization" in 1907. Fifty-three papers are included in this report and others were presented which will be published elsewhere. The Society is to be congratulated on the interest which it has shown through a quarter of a century in the promotion of science. The results of the Conference have demonstrated the true vision of its organizers.

In this volume are many papers on the broader aspects of the problem such as that by P. Bois who reviewed the causes of sterility, the expression of sterility and the French studies on the subject, that by A. B. Stout on types of sterility, that by G. Tischler on the causation of gametic sterility, that by A. C. Beal on the role of sterility in the breeding of flowers, that by F. J. Chittenden on sterility in fruits, that by C. E. Myers on the role of sterility in the improvement of vegetables, that by M. J. Sirks on the problems of self and cross-incompatibility. There are many papers on certain aspects of the problem or the problems as they affect certain plants. The extent of the interest in and work on sterility may be gathered from the list of names of plants mentioned in the titles, which list would be extended by hundreds if all those discussed in the text were listed.

In the titles are the following:

Fruits
Rubus
Fragaria
Citrus
Apple (4 papers)
Pear (3 papers)
Plum (2 papers)
Cherry (2 papers)
Raspberry
Strawberry
Filbert
Date
Peach
Date
Grape

Flowers
Rose (2 papers)
Dahlia
Peony
Carnation
Aster
Cleome

Vegetables
Beet (2 papers)
Celery
Cabbage (2 papers)
Onion
Potato

Other plants
Johnson grass
Gossypium
Datura (2 papers)
Trifolium
Melilotus
Veronica
Nicotiana
Shepherds purse
Lysimachia

All interested in the general problems of sterility or in sterility of particular plants will wish to have this report.

—*Geo. M. Darrow.*

**Memoirs of the New York Horticultural Society*, Volume 3. Papers presented at the International Conference on Flower and Fruit Sterility, August 12-14, 1926. Pp. xi+408. New York. 1927.

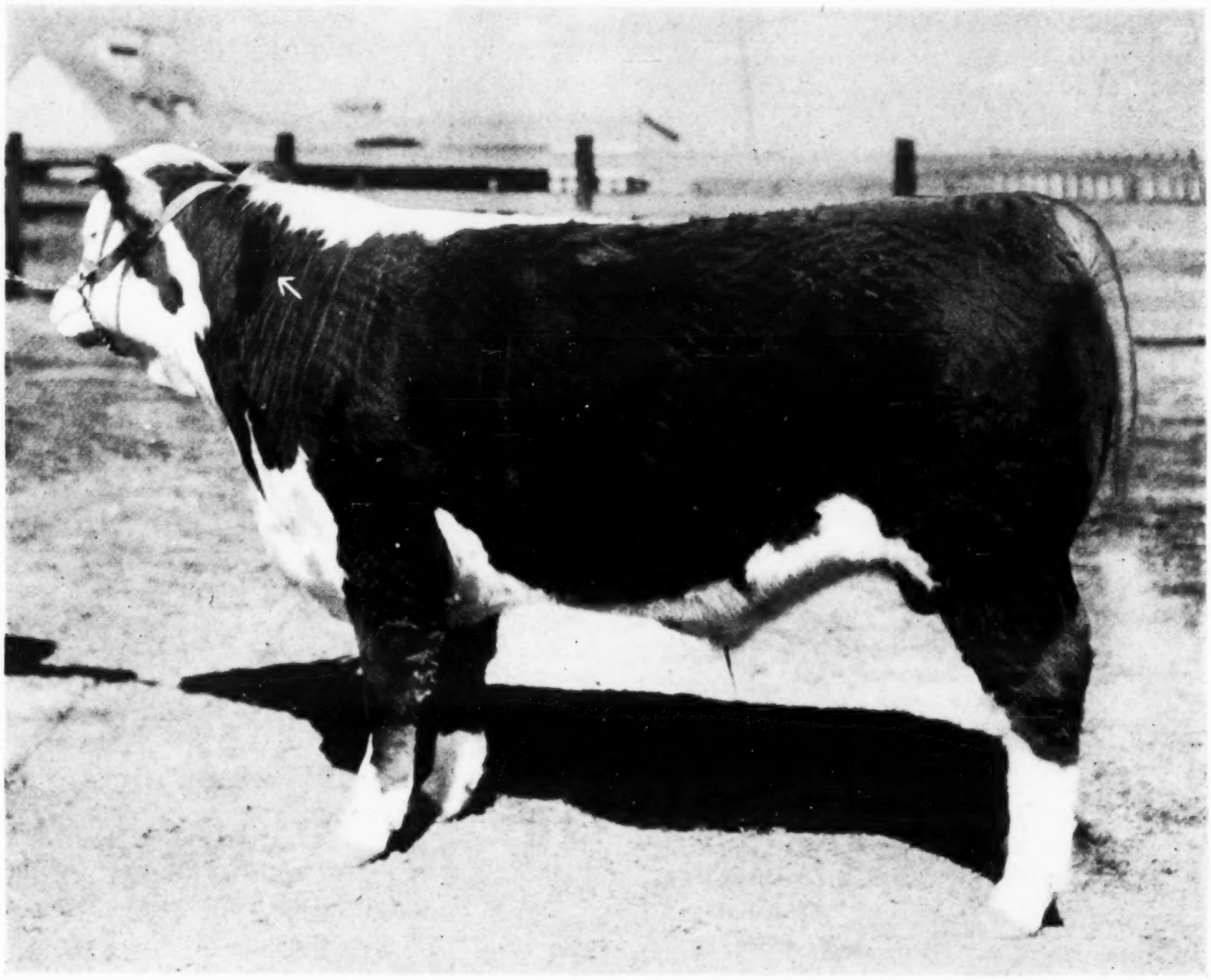


Figure 6

Exceptional Color Inheritance in Hereford Cattle

RED coat color in cattle behaves as a simple recessive to black. A red animal is homozygous recessive for the allelomorphic pair involved. The appearance of an area of black (the dominant color) on an animal which is otherwise red (the recessive color) is a situation which cannot be accounted for by the accepted explanation of the genetic relationship of the two colors.

A purebred Hereford calf, Bonny Anxiety 10th, in the herd of the Department of Animal Husbandry of the A. & M. College of Texas, has a black spot on the left side of his neck, as shown in the illustration. The black area is 17 cm. long by 8 cm. wide. Superficially, it appears to be completely black, but close examination shows a few short red hairs mixed in with the black ones. The skin pigmentation under this black area is the same as that under the red on the animal. No black area is found in either of the parents, nor is any known in any of the ancestry.

Animal Husbandmen report that similar black areas appear occasionally on Herefords and also on red Shorthorns. They do not know whether or not there is a tendency for such black spots to run in certain families.

The photograph of Bonny Anxiety 10th was taken with a Wratten A filter in order to make a distinction between red and black.

W. R. Horlacher,
Texas A. & M. College.

AN OPEN SESAME TO HEREDITY

A Review

FOR the past twenty-five years there has been an intense and highly profitable activity in the study of heredity. As a result the specialists in this subject have developed what is for them a very satisfactory picture of the processes involved in the transmission of characteristics from one generation to another. Up to the present time this picture has been visible chiefly to the geneticist.

In a truly large number of organisms the geneticist can predict now with mathematical exactness the type of offspring that will result from a given mating, and the list of organisms for which this knowledge is available is growing steadily.

Despite the great accumulation of information on the subject of heredity, the existence of the phenomenon is either denied, or its importance discounted, by many otherwise intelligent people. Even those who accept heredity as an established fact consider the whole matter as very much of a mystery incapable of rational generalization.

For those who deny heredity there is probably no cure, for they will continue to reject the known facts, but for the others, who lack only an understanding of the methods used in the solution of the problems of descent, relief is now available. There is no longer a valid excuse for hazy-mindedness with respect to the mechanics of inheritance, for Professor East has published a delightfully instructive book which treats of these matters in easily understandable language shorn of all technical terminology.*

Professor East has written what the publishers call the primer of genetics, but for once the "blurb" understates the facts. The book actually constitutes a liberal course in heredity yet the reader is spared tables, diagrams and formulae! Were the book not an accomplished fact one would state unhesitatingly that an understandable picture of the fundamentals of inheritance could not be sketched by means of words alone. Yet this book proves that it can be done, and done well.

Professor East is one of the outstanding pioneers in the modern science of genetics and much of the progress made in this field is due to his experimental acumen. The public then is doubly fortunate to have a clearly written treatise by one of the science's leading investigators.

The book consists of 324 pages with the index—it needs no glossary.

The various phases of the subject are treated in fifteen chapters including, the Machinery of Heredity, The Grammar of Heredity, Heredity and Sex, Marriage between near Kin, Genius, Mediocrity and Education and ten other equally alluring titles. Chapters 3 to 8, inclusive, recount the existing knowledge of the fundamentals of inheritance and describe how that knowledge was obtained. In these chapters the author appears at his best and no critic, however carping, can find cause for complaint.

When the stage is reached of what is to be done about it one finds more with which to disagree. The ideal Utopia briefly sketched on pp. 240-241, though scientifically sound, would reduce life to an absurdity. Half-wits take too much of our money and thought now, without our attempting to make them efficient and it is proposals of this sort which have placed eugenics in its present unenviable position.

*EAST, E. M. Heredity and Human Affairs. Charles Scribner's Sons, New York. 1927. $3.50.

In the chapter on Education the author clings to the idea that our schools are still attempting to function as educational institutions whereas most modern parents look upon them as day nurseries where children can be placed under the control of public servants during the trying years from five to twenty-five. From this viewpoint they are doing very well and need only some minor reforms such as longer hours, Saturday sessions and shorter vacations.

The reader will recognize the infiltration of H. L. Menken by such words as "wowser," "yokel" and "bozart" but there is very little of this sort of thing for Professor East has a vigorous though somewhat cynical style of his own.

His treatment of Clarence Darrow's "eugenic" briefs* is as skillful a piece of controversial writing as can be found anywhere. In the course of the book he finds occasion to criticize Doctor Jenings for his too sentimental humanitarianism expressed in Prometheus,† and here again one is struck with the nicety with which the point is made. Professor Boaz‡ is given short shift, perhaps too short, and the chief defect of the latter chapters is to be found in the author's frank impatience with those who are not inclined to give heredity what he considers its proper weight in human affairs. Just how Doctor Pearl's recent fall from grace§ can be squared with Professor East's position is a serious question. To the investigator it seems significantly ironical that the country's best-known biometrician should discount biometrics and champion the Mendelianists at the moment when one of the outstanding Mendelianists was writing paeans of praise for the first Biometrician. It looks very much as if each investigator, familiar with all the colored gentry in his own woodpile, has assumed that his neighbor's woodpile is unpopulated.

One who keeps abreast of the eugenic literature may find himself in a confused state of mind by this apparent lack of agreement between such leaders as East and Pearl on some of the fundamental questions of the science.

The reader's dilemna is not wholly without cause for where East shows beyond cavil that our great men are descended from outstanding ancestors and predicts that future geniuses will come largely from the best family stock of today, Pearl just as convincingly maintains the contrary.

The disagreement between these two authorities is more apparent than real and one should bear in mind that where Pearl is a philosophical optimist with an incorrigible desire to upset the apple cart, East is a philosophical pessimist with less ebullient spirits. Pearl appreciates that the men of distinction furnish a larger proportion of distinguished offspring than do the mediocre but he rebels at the insinuations that all great men are descendants of great parents. It seems true that the greatest number of contributors to world advancement had humble origins, in the sense of undistinguished forebears, but this is to be expected when one recalls the paucity of outstanding ancestors as compared with the population at large.

Were Doctor Pearl obliged to select an infant who at maturity would be distinguished he would undoubtedly make his selection from the offspring of the men of note, realizing full well that his chances of success would be fifty times greater than if he chose

*Darrow, Clarence. The Edwardses and the Jukeses. *Amer. Mercury* 6:147-157. 1925. The Eugenics Cult. *Amer. Mercury* 8:129-137. 1926.

†Jennings, H. S. Prometheus, or Biology and the Advancement of Man. New York. Dutton. 1925.

‡Boaz, Franz. Changes in Bodily Form of Descendants of Immigrants. *Sen. Doc.* 208, Washington, 1911, p. 573.

Pearl, Raymond. The Biology of Superiority. *Amer. Mercury* 12, No. 47, Nov., 1927.

from the ranks of the unknown. Both East and Pearl have the same facts with which to deal and their divergent reactions result from their different metabolic rates. It is possible that impending conditions are not quite so bad as Professor East believes nor quite so rosy in hue as Doctor Pearl affects to see them. This uncertainty of the exact color of the future does not seriously detract from the value of Professor East's book, for after all it is addressed to people of discrimination and they alone are entrusted with the task of shaping the proper course to pursue.

Although the author may at times overemphasize the rôle of heredity, at the expense of internal secretions and external environmental effects, he nowhere assumes the heritable nature of the desire to go to sea. Professor East may be pessimistic but he is not ridiculous.

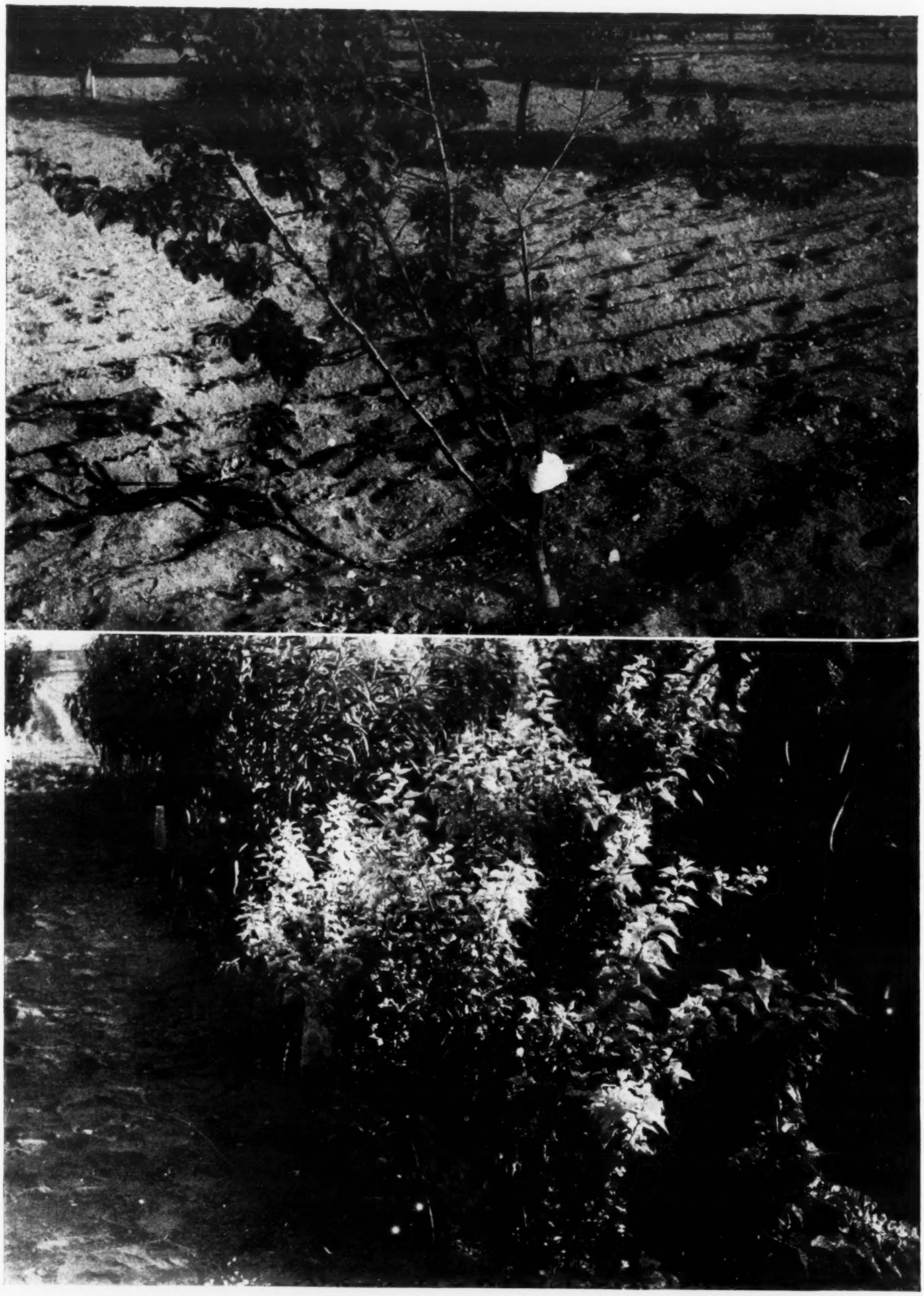
At times the argument borders on the specious as when he points to the futility of sterilization as a means of eliminating the undesirables. Here he contends that segregation and recombination will keep us supplied always with about 20 per cent unfit despite sterilization, and later shows, just as effectively, that the self-imposed sterilization of the genius is ridding the world of this highly desired germ plasm.

The facts are, of course, that sterilization at either end of the intellectual scale will result in a gradual reduction of the sort of germ plasm represented by the sterilized, the rate depending upon the efficiency and rigor with which the selection for sterilization is conducted. Segregation and recombination of Mendelian units can be relied upon to conserve the worthwhile as well as the degenerates.

In the final paragraph the author summarily dismisses as nonsense the criticism that geneticists can not distinguish the fit from the unfit. He has our sympathy here for we have been persuaded to agree to the ruthless elimination of the unfit, but we feel betrayed when we find that the fit consists of such men as William James and Francis Galton and we shudder at the solemn silence which will enshroud our now populous districts.

There are, perhaps, a few other minor points to which many readers will take exception such as the author's wholehearted belief in the omnipotence of the psychologists, but these are all inconsequential when considered from the standpoint of the entire book. Professor East is to be congratulated on having produced a work of such exceptional merit and the purchasers, of whom there should be legion, have several fascinating hours in store for them. Despite the low level of intelligence throughout the land we predict a prominent place for *Heredity and Human Affairs* in the Bookman's monthly score.

J. H. Kempton.



APRICOT MUTATIONS

Figure 7

(Above) A mutant branch on a tree of the Royal Apricot. The aberrant branch is distinguished by the handkerchief. The mutant is characterized by dark green, crinkley leaves and relatively weak growth. (Below) A nursery row of variegated-leaved apricots perpetuated by budding from a mutant twig having the same character of foliage.

TWO APRICOT MUTATIONS

GEORGE P. WELDON

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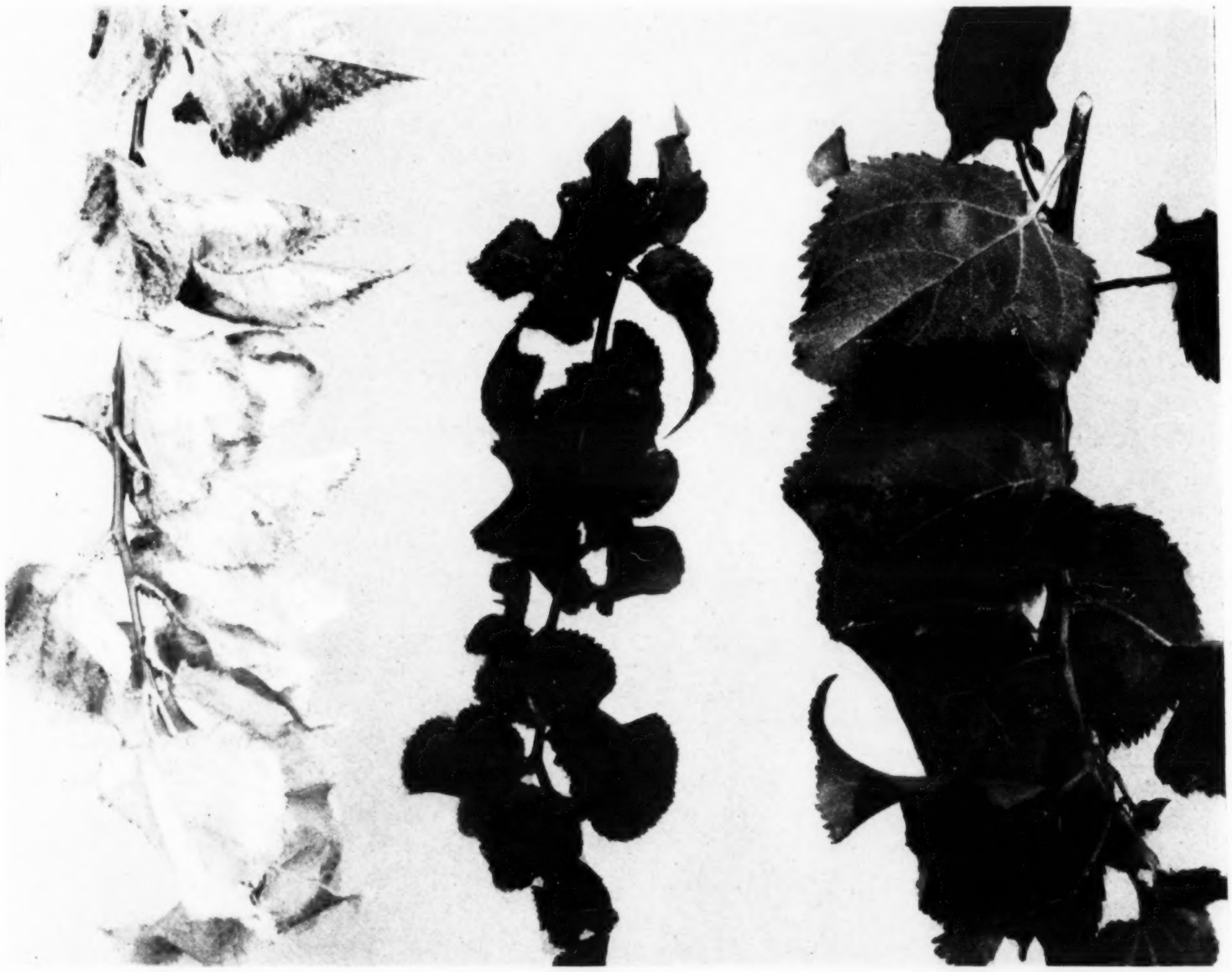

LEAVES OF MUTANT APRICOTS

Figure 8

At left: Variegated foliage twig taken from progeny tree perpetuated by budding from mutant twig; Center: Small crinkled dark foliage taken from mutant part of young apricot tree. Right: Normal foliage taken from the same tree.

IN previous articles* in the JOURNAL OF HEREDITY on "Instability in Peach Varieties," the writer described two mutations and called attention to the apparently greater frequency of occurrence of deciduous mutations than has generally been supposed. Brief mention is being made in this article of two apricot mutations to further emphasize this frequency.

During the summer of 1922 my attention was called to a particular variant tree in a nursery row of Royal apricots. Seedling trees had been budded to this variety the previous fall, and were, therefore, making their first year's growth from the bud. The variant tree had grown from the bud in a normal manner, and the growth of the main stem for about ten inches above the bud was normal. Also lateral branches from this portion of

**Journal of Heredity*, 15:86-90, February, 1924, and 17:133-135, April, 1926.

the stem were typically Royal apricot, both with respect to bark and leaf characters. Beginning at a point approximately ten inches from the point of bud union an entirely different type of growth occurred. The possibility of a periclinal chimera instead of a mutation was considered. However, the leaves of the mutant branch were unlike the leaves of seedling apricots upon which stock the budding was done. The departure from the apricot type of leaf was quite striking, and the dark green, crinkled leaves resembled plum as closely as apricot. The tree was marked and when dormant was moved to the experimental orchard of Chaffey Junior College where it is now growing. Propagations were made from the normal Royal apricot part of the tree and the mutant part. Progeny trees in each case were typical of the parts of the tree from which the buds were taken. The very small, dark, curled foliage caused the mutant progeny to stand out in marked contrast to the Royal trees as they grew side by side in the nursery row.

The second apricot mutation propagated is of interest because it possesses variegated foliage. The original mutation was discovered in May, 1925, by Mr. C. S. Pomeroy, while he and the writer were looking over some eleven year old Royal apricot trees growing in an orchard. One little twig was noticed, which was scarcely more than a foot in length at the time, every leaf of which was light in color. Toward the growing tip there was almost a total absence of chlorophyll and the leaves appeared very light yellow, or almost white. The older leaves toward the center were nicely mottled with green and white, the white still predominating. Toward the base where the oldest leaves occurred, the green color predominated. A bud stick was taken from the twig in September and ten buds were inserted in some seedling peach trees. All of them grew, with the result that ten progeny trees were secured, all of which bore very light colored variegated foliage, proving the stability of the character.

Neither of these mutations have fruited, so that nothing is yet known about the fruit characters, which will be noted with interest after the trees come into bearing.

Nordic Anthropology

GÜNTHER, HANS F. K., KLEINE RASSENKUNDE EUROPAS. Pp. 213. 8 marks. J. F. Lehmann, München, 1925.

The author of this book is well known as one of the principal leaders in the propaganda for the "Nordic" race. His description and classification of the European races is dictated predominantly by prejudices springing from this myth. Seen from the geneticist's view, the value of the book is very small indeed. However, since the Nordic folly appears to be going out of fashion quietly and quickly, even a warning signal may be outdated at this time. The book contains a great number of good pictures which should be of value to those interested in European anthropology.

W. L.

VARIATION IN SPINACH SEEDS*

Leptokurtic Curve Indicates That Two-Spined Character Is Little Affected by Environment

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SINCE 1922 sex characters in spinach has been the subject of the writer's investigation, and when examining the flower parts he noticed an abnormal variation in a certain character of the fruit, which will be reported in the present paper.

As is well known, there are two types of fruit character in spinach, round-seeded type and prickly-seeded type. In the latter type the number of spines is more or less variable, and it is noteworthy that it represents an abnormal variation corresponding to a leptokurtic curve.

Dispersion in the Number of Spines

Reports on the number of spines in spinach have already been made. For instance, according to Volkens[7]† it is normally 2, and occasionally 3 or 4, and Kondo[2]† in his study of 4795 seeds found the greatest part of them two-spined, while some had from 3 to 6 spines.

Examining 53399 grains (ca. 2 liters) in 1922 and 40149 grains (52 plants) in 1924, the results obtained are in accord with those of other authors in that two-spined fruits predominate. The dispersion was much greater than ever before reported, both in a negative and positive direction. It ranged from 0 to 8, so that the dispersion toward the positive direction is greater than toward the opposite direction. Fruits with the respective numbers of spines are shown in Figure 9, and the numerical result of the examination is given in Table I.

Seeds used in 1922 were obtained from a seed dealer in Sapporo and as a result of the examination 531 spineless seeds were found, but it seemed very probable that these were mostly seeds of the round-seeded variety, which is the common type of market spinach here. They were submitted to careful inspection repeatedly, and by planting some of them it was confirmed that most of them belonged to the round-seeded variety and only 5 proved really to belong to the prickly-seeded variety.

From the above data the more important biometrical constants were calculated with the results shown in Table II.

In such an extraordinarily abnormal variation calculation of the probable errors was considered unnecessary. Plus signs in skewness indicate they represent curves which are skew in the positive direction and tail off more to the high values.

There is a fair agreement between

Table I.—Distribution of Spines on Spinach Seed

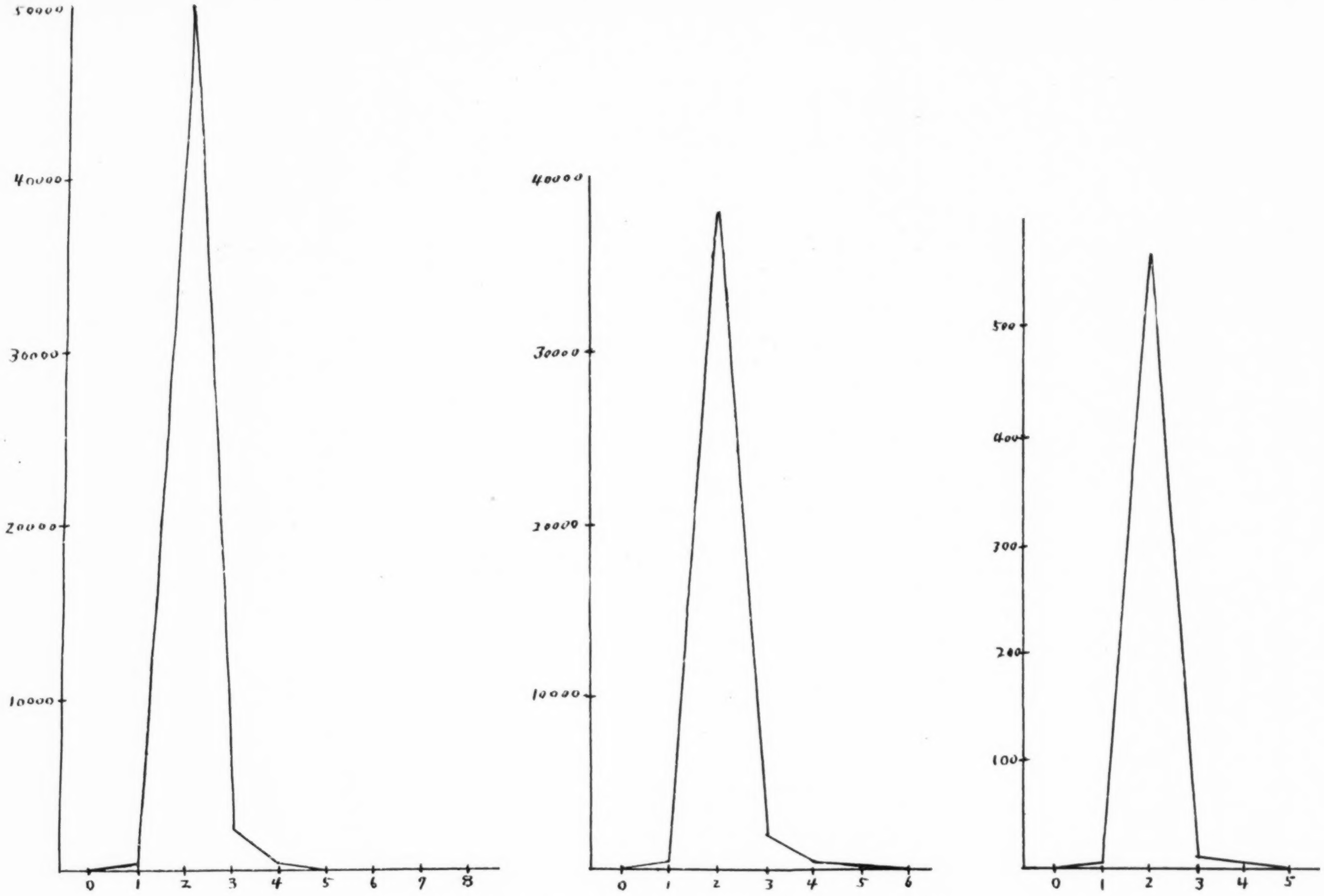
1922									
Number of spines	0	1	2	3	4	5	6	7	8	Total
Frequency	5	232	50297	2427	397	33	6	1	1	53399
1924									
Number of spines	0	1	2	3	4	5	6			Total
Frequency	4	269	37433	2085	331	23	4			40149

Table II.—Biometrical Constants

Year	*Mean*	*Standard Deviation*	*Coefficient of Variability*	*Skewness*
1922	2.0583	0.2916	14.1656	+2.2840
1924	2.0637	0.3077	14.8841	+1.9581

*Briefly reported at the associate meeting of Society of Agriculture and Forestry, Sapporo; Agricultural Society, Tokyo; and Japanese Society of Agricultural Chemistry, held in Sapporo, August, 1925.

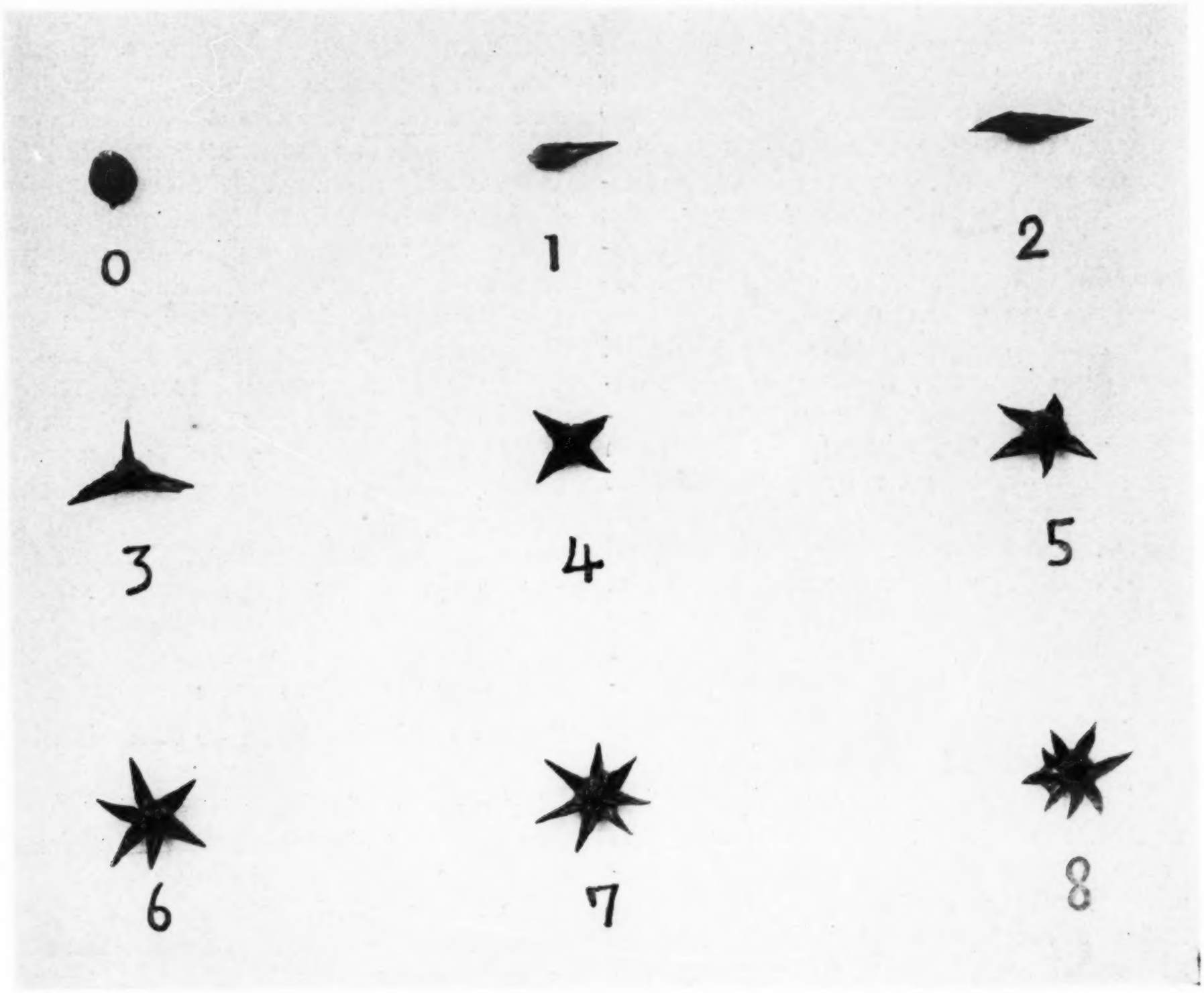
†Reference by number is to "Literature Cited."



LEPTOKURTIC CURVES OF SPINE DISTRIBUTION

Figure 9

At left, distribution of number of spines of 53,399 spinach seed examined 1922; in center, the same for 40,149 seed examined in 1924; at right, distribution for 592 seed from plants grown in sand. The peaked curve of this type, where a great majority of individuals are found closely grouped about the mode, is called leptokurtic. Such a curve is produced in plotting a character which is very little affected by environmental factors.



VARIATION IN NUMBER OF SPINES ON SPINACH SEEDS

Figure 10

The great majority of spiny-seeded spinach seeds have two spines (see fig. 9).

the results for the two years, excepting with respect to skewness, in which a somewhat marked difference is observed due to the greater tailing-off in the 1922 material.

Kurtosis

Kurtosis is the name given by Pearson[5] to the feature of curves relative to the degree of flatness in the region about the mode as compared with the condition found in a normal curve, and a curve more peaked than the normal curve is said to be leptokurtic.

Instances of leptokurtic curves have frequently occurred in studies of variation in plants as well as in animals. To cite a few examples in plants, Ludwig[3] found them with respect to number of ray-florets in *Chrysanthemum segetum*, etc., and Johannsen[1] in the seed weight of French beans. However, such a remarkable example of kurtosis as presented in this paper seems rather rare. So far as the writer is aware, the case found by Vöchting[6] in the number of corolla points in Linaria is the most striking, even more pronounced than in the case of the spinach cited here. In Figure 9 curves plotted from data for 1922 and 1924, respectively, are given.

Kurtosis has been calculated by the formula.

$(N = B_2 - 3.)$

While in a normal curve this value is 0, in the data on spinach it is +32.4962

and +22,9486 in 1922 and 1924, respectively, both showing a considerable degree of kurtosis. Probable errors for normal curves with 53399 and 40149 observations were calculated and found to be ±0.0143 and ±0.0142, respectively, and kurtosis in these two cases is 2272 and 1616 times the probable error, respectively, indicating a considerable degree of kurtosis.

In the foregoing case the standard deviation is small, the number of variates falling outside 3 σ being comparatively large, thus justifying the term "Exzessivität" given by Johannsen to such a variation.

The normal curve may now be fitted to the observed variation. However, here the index of abmodality for class interval is so large, i. e., 1/ σ is 3.4294 in 1922 and 3.2499 in 1924, respectively, as to make the process unnecessary.

Cause of Leptokurtosis

If a combination of independent environmental factors, each having no preponderant effect, operates to determine a certain character of organisms and they act in such a way that some of them have plus and some minus effects on the character in question, and are cumulative, then modifications thus induced exhibit a regular distribution so as to be represented by a normal curve. However, if among various combinations of factors only extreme ones can induce variations, while those lying between two extremes remain almost ineffective, then variations corresponding to leptokurtic curves result. In spinach two spines is a remarkably fixed and unmodifiable character and it can be changed only by extreme combinations of environmental factors, resulting in leptokurtosis. Ludwig[4] calls such a curve "hyperbinomiale Kurve" and explains it by the existence of numerous non-variable or only slightly variable individuals, i. e., "Invariant." Johannsen[1] in the second edition of his "Erblichkeitslehre" criticized this explanation as inadequate and suggested his own explanation. In the third edition, however, he did not contradict Ludwig's opinion, and only suggested that the occurrence of individuals or biotypes deviating strikingly from the mean was at least a cause of leptokurtosis. This suggestion explains why he thinks the term "exzessive Kurve" most adequate to denote this type of curve. It seems, however, that Johannsen explains only the special nature of variation as such and not the underlying cause. With respect to the cause of leptokurtosis the explanation given by Ludwig (originally suggested by Verschaffelt) seems most adequate.

Relation of Nutrition to the Number of Spines

It may be of some interest to test whether the deficit in nutrition may exert any influence upon the number of spines. In 1924, 292 spinach plants were grown in a sand bed with the idea of furnishing as little nutrition as possible. Under this condition the height of plants averaged around 5 cm., and number of fruits per plant ranged from 1 to 6, generally 2 or 3. The variation in the number of spines and constants determined therefrom are shown in Table III.

From these data it is established that even in the case of spinach grown under conditions of extremely low fertility the two-spined character occurs with greatest frequency, while the dispersion tends to decrease, especially in the positive direction. This accounts for the low value of the standard deviation and coefficient of variability and the high value of kurtosis, as compared

Table III.—Variation in Number of Spines in Plants Grown in Sand

Number of spines	0	1	2	3	4	5	Total
Frequency	0	3	573	12	4	0	592
Mean							2.0287
Standard Deviation							0.2269
Coefficient of Variability							11.1845
Skewness							+2.9215
Kurtosis							+44.2143

with these values when spinach was grown on highly fertilized soil. It may follow that high nutrition and other conditions favorable for the growth of spinach increases the number of spines, and vice versa. Number of flowers in a given flower cluster may also affect number of spines both physiologically and mechanically. Unfortunately, the 1924 material was damaged somewhat from shattering, so that accurate observations could not be made. However, so far as the writer's observation goes, no correlation could be found between number of spines and position of fruit attachment on the plant.

Summary

1. Spinach exhibits variation in the number of spines corresponding to a leptokurtic curve.
2. The variation takes two spines as the modal value and shows dispersion ranging from 0 to 1 and 3 to 8 in negative and positive directions, respectively.
3. Kurtosis in 1922 and 1924 material amounted to +32.4962 and +22.9486, respectively.
4. Kurtosis can be explained by the assumption that the two-spined character remains exceedingly constant and can be changed only in a slight degree by the combination of extreme environmental factors.
5. Kurtosis can be observed even when spinach is grown in soil of extremely low fertility.

The writer acknowledges the valuable assistance of Messrs. T. Sakamoto, S. Nakamura, and S. Yoneda in the examination of seeds used.

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Mongolian Idiocy in Twin

Mitchell and Downing (*Am. Jol. Med. Sci.*, Dec. 1926) report a case of mongolian idiocy in one of twins whose sex was identical. The birth of the twins was uneventful. The twin brother was not a mongol and continued to develop normally both physically and mentally. The authors favor the theory that mongolism is a germ plasm defect, and are against any theory which holds that causes operative during pregnancy are at fault. In none of the cases reported has it been demonstrated that mongolism can occur in one of twins the result of a single-ovum pregnancy.

—*Jol. Am. Med. Assoc.*

Sun Not Son

HOW to determine or influence the sex of unborn children has been the subject of much parental thought throughout the ages. The great interest manifested in the sex of future children has stimulated many earnest souls to devise sex control schemes and systems fully as fantastical as they are foolish. All methods have ardent devotees who seldom are discouraged when the magic fails, and, like religious fanatics are well prepared with plausible explanations.

The latest of these offerings is a well-manufactured book entitled "The Cause and Control of Sex in Human Offspring" by R. Clay Jackson.* The author's thesis is that males produce only males and females only females. That these opposite tendencies of the two sexes fail to result in bisexual offspring is due to the kindly interposition of the sun with the more or less trifling aid of fatty tissue and of complexion. That the author has been able to make even the semblance of a case out of this curious hodgepodge of materials is a tribute to his skill.

Briefly the sun's rays are fatal to germ tissue. Males laboring in the sun have their gametes altered from male to neuter, a condition which permits the female gametes to take precedence and the result is daughters

Where the males are light in weight or work in the dark the situation is reversed and only sons are born.

That the world is not composed largely of females is due (1) to occupations such as mining, (2) to cloudy weather, (3) to the resistance offered by fatty tissue to the sun's rays and (4) to the protection afforded by certain complexions.

Where two parents are of nearly the same weight and complexion with equal exposures to the sun the resulting children frequently perish, due to the conflict of the sexes.

The treatise is presented in a very plausible manner. The author maintains a deceptive appearance of disinterestedness and is the past master of reasoning by anecdote, as witness the following: "Case 33. The father worked for seven years as a driver on a bakery and milk wagon. He weighed about 185 pounds and his complexion was quite sandy. He had blue eyes. Two girls of six and four years were the issue in this case. The mother weighed about 140 pounds and was a medium light brunette. I marvelled at this situation, which incidentally was about to cause the disruption of the family, for it seemed that the father's weight and blondness should have yielded him preferably a son despite his outdoor work. I was deeply puzzled until one who had long known the family informed me that until the time of their union the mother had been a school teacher!"

The modern writers on sex control, Whitman, Riddle, Morgan, Wilson, et al. are considered and the defects of their reasoning pointed out.

The book contains a glossary, an index and a chronology! (which includes the itinerary of the manuscript). Just why no publisher could be found for this lucrative work is as mysterious as the effect of a greenhouse environment on sex.

J. H. K.

*R. Clay Jackson. The cause and control of sex in human offspring. 205 p. $5.00 Tacoma, Washington. 1926.

NATURAL AND ARTIFICIAL HYBRIDS OF A CHINESE WHEAT AND RYE

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THREE natural wheat-rye hybrids found in 1914 in plats of wheat on Arlington Experimental Farm, near Washington, D. C., apparently were the first ever reported in this country, although a few such hybrids may have been observed previously in Europe. Since 1914, similar natural wheat-rye hybrids have been found annually on Arlington Farm; in some years hundreds of them have been observed. Most striking, however, is the mass appearance of such natural hybrids reported by Meister in the Journal of Heredity of December, 1921. In 1918, as many as 20 per cent of the plants in certain plats of winter wheat on the experimental station at Saratov, Russia, were natural wheat-rye hybrids.

Experiment on Frequency of Crossing

The frequent appearance of wheat-rye hybrid plants among the wheat cultures at Arlington Farm suggested an experiment to determine the exact percentage of crossing under what were considered optimum conditions. Accordingly, in the fall of 1923, eight varieties of wheat—Shepherd, Currell, Nittany (Pennsylvania No. 44), Mammoth Red, Purplestraw, Leap and China—were space-planted in single rows 18 feet long. In one plat Abruzzes rye was planted in alternate rows with the wheat varieties, and in a second Rosen rye was used. The wheat and rye rows were one foot apart. These wheat and rye varieties vary sufficiently in their blooming dates so as to afford ample opportunity for crossing, at least between some of the plants.

At maturity all of the wheat plants were harvested individually and threshed in a plant thresher. The grain was cleaned carefully before a fan so as to avoid loss of any small, poorly developed hybrid seed. The following fall of 1924 the seeds from these plants were carefully space-planted in 18-foot rows. From a total of 27,610 seeds planted, 24,883, or 90.11 per cent germinated and about 20,000 plants matured. Not a single wheat-rye hybrid occurred among these plants—not even in Purplestraw, the variety that produces more than 95 per cent of all the natural wheat-rye hybrids found at Arlington Farm.

Although the experiment outlined above may not have furnished optimum conditions for the production of natural wheat-rye hybrids, doubtless abundant opportunity for crossing was presented. The results obtained indicate that natural crossing between wheat and rye is comparatively rare. From observations made at Arlington Farm, however, it appears that at least one kernel in 20,000 in the Purplestraw variety of wheat may be of such hybrid origin in certain years. Under exceptional conditions hybridization may be much more frequent, as the following observation will show.

Natural Hybrids in a Chinese Wheat

In 1925, a 16-foot row of a Chinese wheat (C. I. No. 6223) contained 129 plants, of which 23, or 17.8 per cent were F_1 wheat-rye hybrids. This row had been sown the previous fall with seed grown in the cereal nursery on Arlington Farm. In this year (1924) a 10-foot row of this Chinese wheat was grown as one of a series of wheat rows directly south of and separated only one foot from about 50 rows of several varieties of rye just introduced from foreign countries. All of the

wheats were sown on October 13, 1923, but the ryes were sown on several dates from October 13 to November 15, thus providing plants whose period of blooming coincided with that of the Chinese wheat. In threshing the crop of 1924, special care was taken to prevent any loss of seed, as some of the varieties grown in this plat were poorly adapted to the environment and contained many shriveled kernels. Consequently, the wheat-rye hybrid seed, which is usually somewhat shriveled and poorly developed, was retained and sown in the fall of 1924. It is very probable that wheat-rye hybrids would be observed more generally were it not for the fact that the small, light kernels are usually blown or screened out in threshing and cleaning wheat used for seed.

Following the discovery of such a large number of wheat-rye hybrids in the Chinese wheat in the crop of 1925, further experiments were begun with this wheat. Accordingly, in the fall of 1925, all of the Chinese wheat seed remaining from the crop of 1924 and from which the unusual number of wheat-rye hybrids referred to above were obtained, was planted. Among the 91 plants produced the following year, 17 wheat-rye hybrids, or a percentage of 18.7, were found. This is in very close agreement with the 17.8 per cent found in the 1925 crop.

The meterological conditions prevailing during the period from May 20 to May 30, 1924, at which time the natural crossing herein reported probably took place, are worthy of note. A total of 2.52 inches of rainfall was reported for this 11-day period, the precipitation being distributed over 7 days, with 4 days on which no rainfall occurred. The temperatures for this period were somewhat low, but apparently not so low as to prevent fertilization. The prevailing winds were from the northwest, which favored the transportation of rye pollen to the flowers of the Chinese wheat, which was growing directly south of the rye.

A consideration of the climatological data for the whole month shows that there were 14 completely cloudy days, 9 partly cloudy days and 8 clear days. The average mean temperature for May was .3° below normal. The precipitation for the month, on the other hand, was 6.73 inches, or 2.90 inches above normal. Sixteen days of the 31 had .01 inch or more rainfall. This excessive rainfall induced considerable lodging, and much of the rye in the series opposite the row of Chinese wheat became lodged upon some of the wheat plants. In addition, the wet weather encouraged the rapid growth of weeds, which caused abnormal development of the wheat plants. Plants grown under the above conditions are commonly found to be partially sterile, and in this condition are readily subject to crossing.

Artificial Hybridization of a Chinese Wheat

Regardless of the conditions which may have favored the natural crossing here reported, the results indicate that this variety of Chinese wheat is unusually compatible to crossing with rye. This was substantiated in 1926, when 33 heads of the same wheat were carefully emasculated, bagged and later pollinated with pollen from Abruzzes rye. From at total of 558 flowers of wheat so pollinated, 462 seeds were obtained. Of the 33 heads pollinated, 6 heads bearing a total of 97 flowers produced 97 seeds or were perfectly fertile. On the remaining 27 heads of wheat from 75 to 95 per cent of the flowers pollinated with rye pollen produced seed, with two exceptions. Among the plants of the Chinese wheat used for hybridizing there were two not typical of the variety. As these appeared to be natural F_1 hybrids between this Chinese wheat and some other variety, a head on each plant, therefore, was used in crosses with rye to determine their reaction. The seed set in these two cases was 9.1 and 18.2 per cent, respectively.

It has been the experience of the writers in crossing a score or more of different varieties of wheat with rye that a seed is obtained once in about

HEADS OF WHEAT-RYE HYBRID AND PARENTS

Figure 11

From left to right, 1 and 2, front and side views of heads of Chinese wheat (*T. vulgare*); 3 and 4, side and front views of heads of the F_1 hybrid between the Chinese wheat and rye; 5, side view of a head of rye (*S. cereale*).

75 to 100 pollinations. If, therefore, a wheat having a potential "crossability" with rye of 100 per cent, such as this Chinese wheat, should be crossed with a wheat having a potential "crossability" of only 1 per cent, the resulting F_1 might be expected to be somewhat intermediate in this respect. It appears that this result has been obtained in the two off-type plants found in the Chinese wheat.

Practically all of the seeds obtained in these experiments in the artificial crosses between the Chinese wheat and rye were somewhat shriveled and malformed, as is characteristic of wheat-rye hybrid seed. On account of this condition, which is recognized by those familiar with such kernels and on account of the special care and attention given in making these crosses, there is little reason to suspect that any of the seeds obtained were not of hybrid origin. Most of the seeds obtained, however, were planted and about 200 plants were matured. All of these were F_2 wheat-rye hybrids.

In view of the fact that this Chinese wheat crosses so readily with rye, its capacity for crossing with another variety of wheat was determined. From a total of 94 pollinations made on the Chinese wheat as a female parent and with another variety of common wheat (R4094) as the male parent, 84 seeds were obtained, or a seed set of 89.4 per cent. It is interesting to note the close correspondence of this figure with that obtained when the Chinese wheat was crossed with rye. Excluding the results with the two off-type plants, the percentage of seed set obtained from crossing the Chinese wheat with rye was 90.5 per cent.

Description of Parents and Hybrids

The Chinese wheat (*T. vulgare*) used in the hybridization experiments herein referred to was obtained from Prof. R. H. Biffen of the School of Agriculture, Cambridge University, Cambridge, England. According to Professor Biffen, this wheat had its origin in Szechuan Province, China. the head (Figure 11) is awnless, clavate, with white, glabrous glumes and soft, red kernels. The flowering glumes, however, have short, strongly in-curved awns from 1 to 4 mm. long. At the base of some awns a thin membraneous outgrowth occasionally occurs; Vavilov likens this to the hood in hooded barley. During several years grown on Arlington Farm, the Chinese wheat has not been very winter hardy, only about 50 per cent of the plants surviving. It is also generally unadapted there.

The rye parents of the natural and artificial crosses possessed the characters usually found in rye, being bearded with white, glabrous glumes, which are elongated and ciliated; peduncle hairy; heads narrow, elongated, with many spikelets (Figure 11).

In general appearance the wheat-rye hybrid is intermediate between its parents, the Chinese wheat and rye (Figure 11). The clavateness of the parental wheat head is usually expressed in the heads of the hybrids. Furthermore, the head is semi-awned, with partially incurved awns, which attain a length of from 1 to 30 mm. The heads of the hybrid are broader than those forms so frequently found on Arlington Farm, which result from the crossing of rye and common wheats with tapering heads. The peduncles of the hybrid are pubescent, as in the rye parent. Most of the hybrids are completely sterile, though some plants produce one or two seeds, probably the result of backcrossing with wheat.

Other Wheats Compatible with Rye

Backhouse* reports that a common wheat (*Triticum vulgare*), of Chinese origin, obtained from Prof. R. H. Biffen of Cambridge, England, set 32 seeds out of 40 flowers pollinated with rye, or 80 per cent fertility, in one experiment; in another experiment 15 flowers of this Chinese wheat polli-

*Backhouse, W. O. Note on the inheritance of "crossability." *Jour. Genetics* 6:91-94, 1916.

nated with rye produced 14 seeds, or 93.3 per cent fertility. The F_1 of a cross between this Chinece wheat and another variety of common wheat, which did not hybridize readily with rye, showed 3.7 per cent fertility when pollinated with rye pollen. Of 17 spikes on as many F_2 plants of this wheat cross, pollinated with rye pollen, 13 produced no seed, while 4 set seed in from 16 to 87 per cent of the flowers pollinated. The inheritance of "crossability" thereby demonstrated, appears to have occurred also in the natural wheat-rye hybrids at Arlington Farm.

Thompson* has recently reported as follows:

> A number of investigators have succeeded in crossing wheat and rye, but only with great difficulty and after many trials. There is a variety of wheat, however, which crosses readily with rye, as high a proportion of pollinations proving successful as in crosses between any two varieties of wheat. This variety I have secured through the kindness of Mr. W. O. Backhouse (1916) of Buenos Aires. By using it as the female parent a large F_1 and a very small F_2 have been produced. From these and from back crosses a great many plants of later generations have been raised.
>
> The wheat used is typical *Triticum vulgare* var. *albidum* Korn. It is a spring wheat of Chinese origin. It shows no peculiarities which would lead one to expect unusual behavior in crossing with either rye or other wheats. The only respects in which it resembles rye a little more closely than do average *vulgare* wheats is in the somewhat more pronounced keel of the outer glume, and the longer, sharper beak of this glume. But many other *vulgare* varieties have these structures as well developed. A marked characteristic of the spike is the sharply incurved, short awns. It behaves like an ordinary variety of *T. vulgare* in crosses with other *vulgare* varieties and with other species of Triticum, except that in certain instances the species crosses are more successful when it serves as one parent.

The Chinese wheat used by Backhouse and by Thompson was originally supplied by Professor Biffen. From an illustration of this Chinese wheat presented by Thompson it is apparent that it is similar to the variety used by the writers in respect to the sharply incurved, short awns. The grain of this Chinese wheat is white, however, and the head is tapering, while the grain of the variety used by the writers is red and the head is more or less clavate.

Summary

Natural crossing between wheat and rye usually is comparatively rare. Not a single hybrid was found in 20,000 plants from seed produced by wheat plants grown in proximity to rye the previous year. In another case, however, about 18 per cent of the plants of a Chinese variety were natural F_1 wheat-rye hybrids.

Of the flowers of a Chinese wheat emasculated and pollinated with rye pollen, 90.5 per cent set seed; when wheat pollen was used 89.4 per cent set seed.

Natural F_1 hybrids of the Chinese wheat used by the writers and another wheat were somewhat intermediate in "crossability" with rye.

*Thompson, W. P. Chromosome behavior in a cross between wheat and rye. *Genetics* 11:317-332. 9 fig. 1926.

THE INHERITANCE OF HUMAN SKELETAL ANOMALIES

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HUMAN skeletal anomalies are malformations of the normal structure due to the influences of heredity or environment. The knowledge of inheritance in man is still very indefinite but abnormalities are conspicuous and can be easily traced from generation to generation. These inherited defects are of interest not only from the standpoint of their pathology but because of the light their mode of inheritance may shed upon the inheritance of normal characters. Morgan has said "in studying the inheritance of each defect we are also studying the inheritance of the normal character."

We are interested here with certain malformations which occur in families and the mechanical mode by which they are transmitted. We do not aim to explain the pathological changes which brought about the variation nor the factors which tend to cause the defect to be present in some and absent in others.

These anomalies, or variations from the normal, represent conditions due to the addition of, or the loss of specific essential determiners. The presence of determiners for a special character may vary in different individuals of a family according to chance distributions and so may be present, one generation after another, or may skip generations. These determiners, therefore, are hereditary and have their origin in the germplasm.

It is of primary importance to first differentiate between the traits of hereditary origin and those due to environmental conditions only. Both types are usually referred to as congenital, since they are both present at birth. However, the term congenital, as used here, will apply only to those anomalies which are present at birth and which are somatic modifications of the foetus. The etiology of such modifications depends on external and internal influences which may be ascribed to infections, inflammations, mechanical injuries and inanition.

There are no criteria by which a clear-cut differentiation can be made between those defects due to heredity and those due to environment, but, a collection of a sufficiently large number of family histories will reveal the mode of transmission, if the trait is due to heredity. Previous observations of the occurrence of certain defects have shown them to meet the Mendelian requirements for dominant and recessive factors.

The accuracy of Mendelian ratios in the study of heredity in man is greatly obscured by lack of data for all members, small families, slow breeding, late maturity, and the inability to subject the human to experimentation. These factors prevent the collection of sufficient data from individual families, therefore, calculations must be based on a large number of family histories which should reveal the mode of transmission if the trait is due to heredity.

Fischer has said that "all known normal and pathological characteristics that are transmitted by heredity follow the Mendelian laws," and on his conclusions we base this analysis of the defects traced through the family histories.

In assembling the various types of anomalies the bone malformations were grouped according to regions of the human body; that is, head, trunk, and extremities.

Anomalies of the Skull

The common anomalies of the skull are hare-lip and cleft palate, dental defects, cochlear malformations, ossifications of the ossicles, and cranial deformities. Those defects discussed here are cleido-cranial dysostosis, depression of the obelion, hare-lip and cleft palate, and dental defects.

Cleido-cranial dysostosis is a rare anomaly of the skull and clavicle which has been reported, up to date, in about one hundred cases. The defect is characterized chiefly by the absence of the clavicles, totally or in part, lack of ossification in the cranial bones, and abnormally large fontanelles. Other malformations are often present.

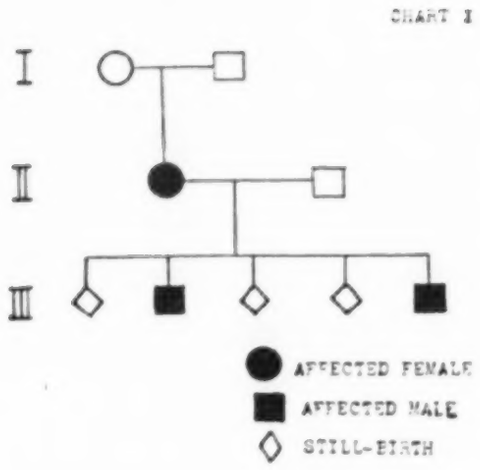
The etiology consists of an incomplete ossification of the membranous bones, the cartilagenous bones rarely being affected. The anomaly has been found in members of families for two or three generations; both sexes were affected, and it has been found in both the black and the white races.

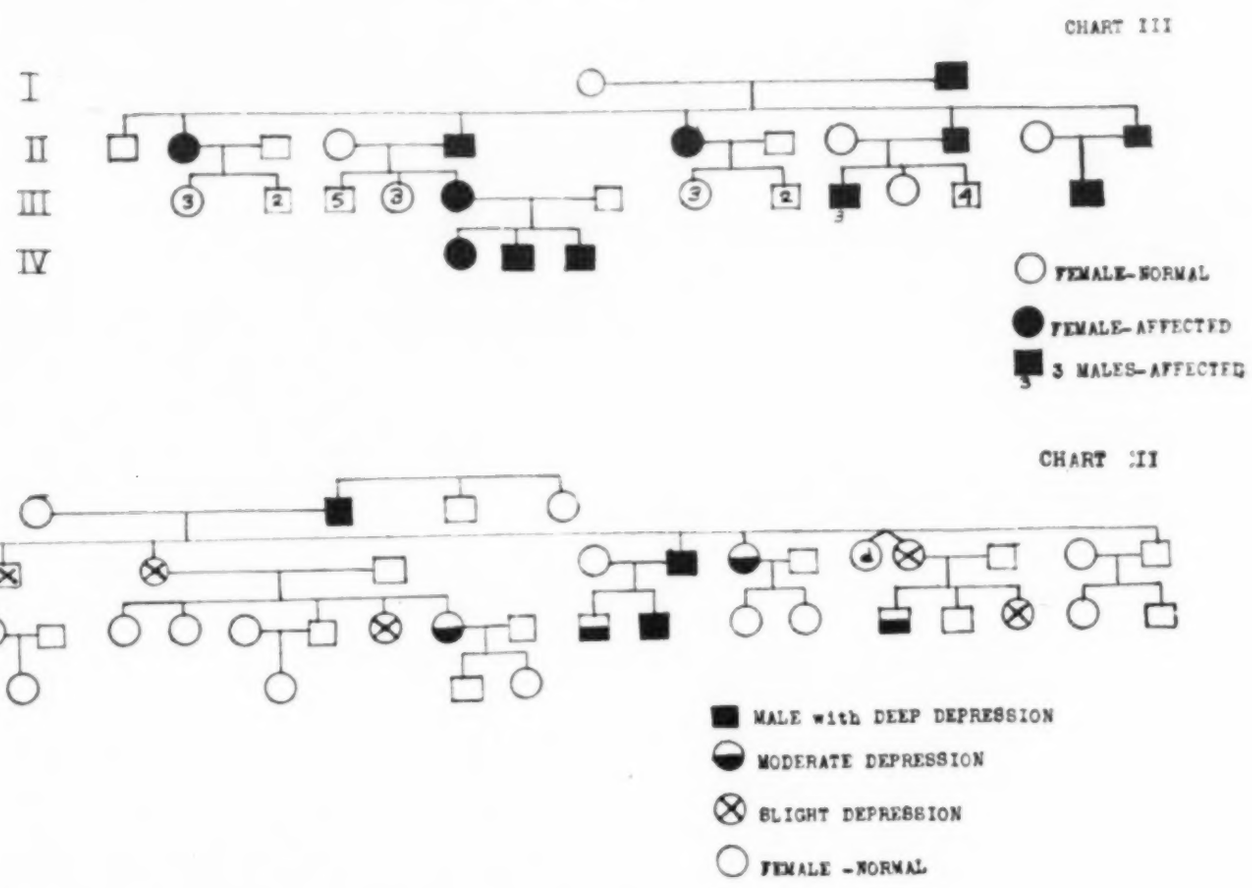
The first case of cleido-cranial dysostosis was reported in France by Martin, 1765, who observed the condition in a father and his two sons. Morand noticed a typical case the next year. Gegenbauer, 1864, and several others later reported the absence of portions of the clavicle in various persons, some cases indicating the hereditary nature of the defect. It was not until 1898 that the pathology of the condition was noted and the anomaly named by Marie and Sainton, who described the condition and established the hereditary facts, recording thirty-one affected persons in eight families. Twenty-three were children of eight affected parents, five mothers and three fathers. They also pointed out that the defect was less pronounced in the children than in the parents. They pointed out the main characteristics of the malformation as, aplasia of the clavicles, exaggerated transverse diameter of the skull, and retarded ossification of the fontanelles. The clavicles were thought to be replaced by fibrous tissue. Scheuthauer, 1899, observed a case in which the inner one-third of the clavicles was replaced by fibrous bands and the anterior and posterior fontanelles were open. A mother and her three children were affected. Hultkrantz, 1899 and 1908, described rudimentary clavicles accompanied by a dislocated humerus and depressed sternum. Villaret and Francoz, 1905, summarized twenty-eight cases, whose families showed 50 per cent of the children affected. They noted seven cases in which one parent was affected. In one case a grandmother and two aunts of the patients were affected; in another case a cousin bore the defect. Fitzwilliams, 1910, summarized the sixty previously reported cases and pointed out the chief characteristics that had been found. Only three individuals had normal skulls when the clavicle was abnormal. In other cases the anterior and posterior fontanelles were very large but they usually closed at about the age of twenty years. In a summary of previously reported cases he found that in 59 families 54 per cent of the children and 23 per cent of the parents were affected.

Langmead, 1916, emphasized the hereditary nature of the anomaly in his report of a family of three generations in which eighteen persons were affected. Four affected parents had fifteen affected children and three normal children. One normal son of an affected parent had two affected children and one normal child.

Delhern, Thoyer, and Rozat, 1921, made a radiological study of a case of cleido-cranial dysostosis which was accompanies by deformities of the scapula and pelvis. The cranial bones were thin, small, and unossified. The scapulae touched along their posterior borders. The pelvis showed aplasia of the ischio-pubis with a marked dysostosis.

Stocks and Barrington, 1925, reviewed the literature on cleido-cranial dysostosis and have given an analysis of the records. They report 96 of the 144 cases on record to be of familial origin. In those cases where one parent





INHERITANCE OF ABNORMALITIES OF THE SKULL

Figure 12

Chart I shows inheritance of cleido-cranial dysostosis in the case studied by the author. Chart II (below) and III show the inheritance of depression of the obelion—Chart II being the case described by the author and Chart III being Stock's case.

was affected, 48.8 per cent of the children showed the anomaly. When the father was affected, 68.8 per cent of the children were deformed, and when the mother was affected, 48.1 per cent of the children were affected.

No case has shown the defect transmitted for more than three generations.

The literature on cleido-cranial dysostosis indicates 60 per cent of the children of affected parents are deformed; 44.3 per cent of the parents were reported to be affected. In no case were both parents affected. The high percentage of affected children may be explained by the fact that the normal sibs were not always included in the history of the case.

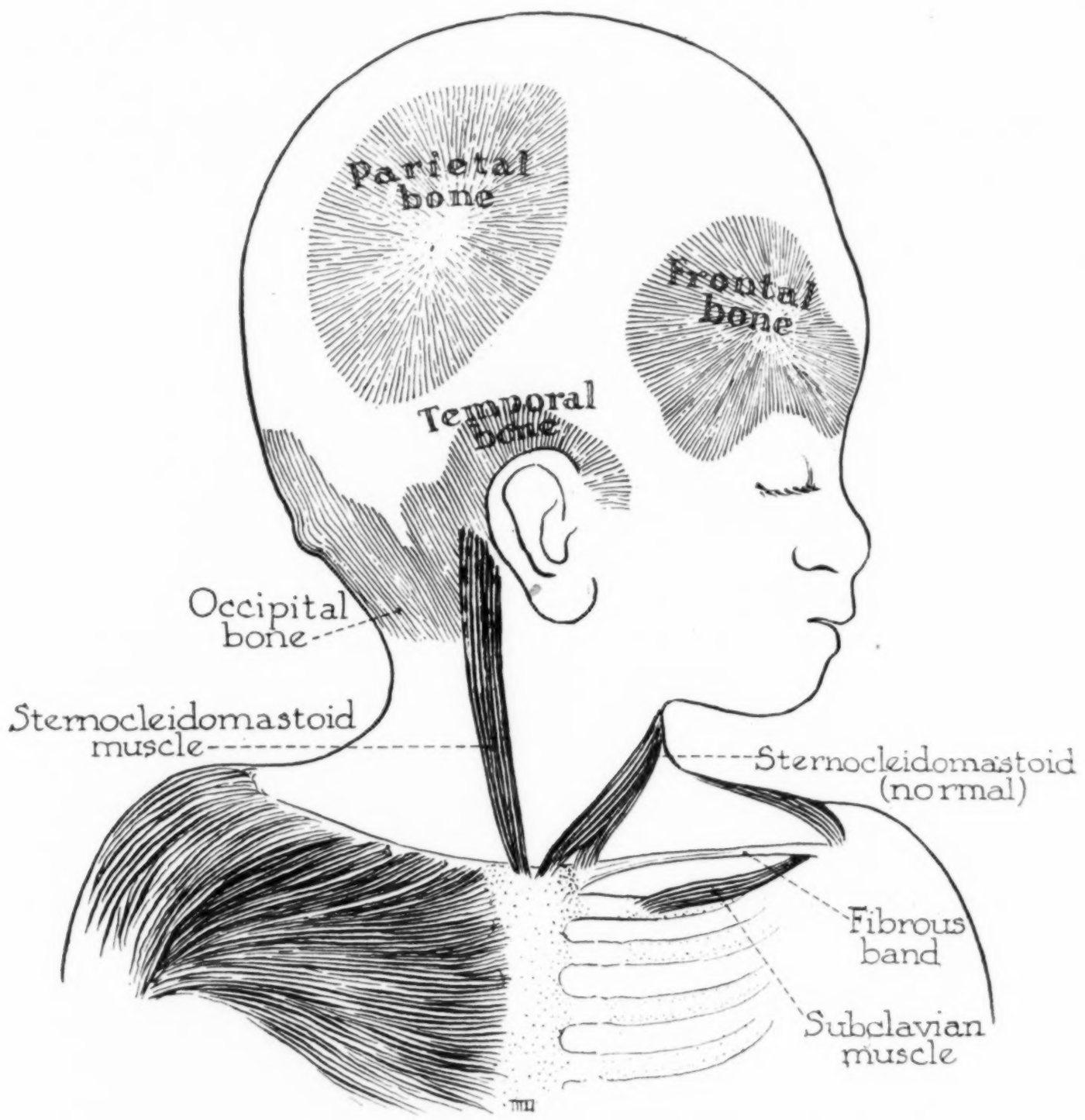
The percentage of affected individuals found in these family histories shows cleido-cranial dysostosis to be inherited as a dominant Mendelian character.

The previous reports have been made from observations of the living person or from the human skeleton, except for the case reported by Scheuthauer, which he dissected. Scheuthauer's dissection showed the inner third of the clavicle was replaced by a fibrous band. The pectoralis major muscle was atrophied and inserted on the under surface of the clavicular ligament. The trapezius muscle was attached to the coracoid process and to the ligament at the sternal end of the clavicle. The cranial malformations were peculiar to the anomaly.

The report presented here is based on the dissection of a seven months' foetus.* (See Figure 13). The clavicles were found to be replaced by fibrous bands extending from the sternum to the acromion. The skull bones were very small, leaving huge fontanelles extending from the glabella to the occipitalis. There was slight ossification at the centers of the bones. The maxillae were not united, but were more advanced in ossification than the cranial bones. There was a cleft, one centimeter in length, of the uvula.

The heads of the sternocleido-mastoid muscle were normal on the left, taking origin from the sternum and from the fibrous band, which replaced the clavicle. The muscle on the right

*Foetus was offered for dissection by Dr. R. J. Terry, Washington Medical School.



CLEIDO-CRANIAL DYSOSTOSIS—A FAILURE IN BONE DEVELOPMENT

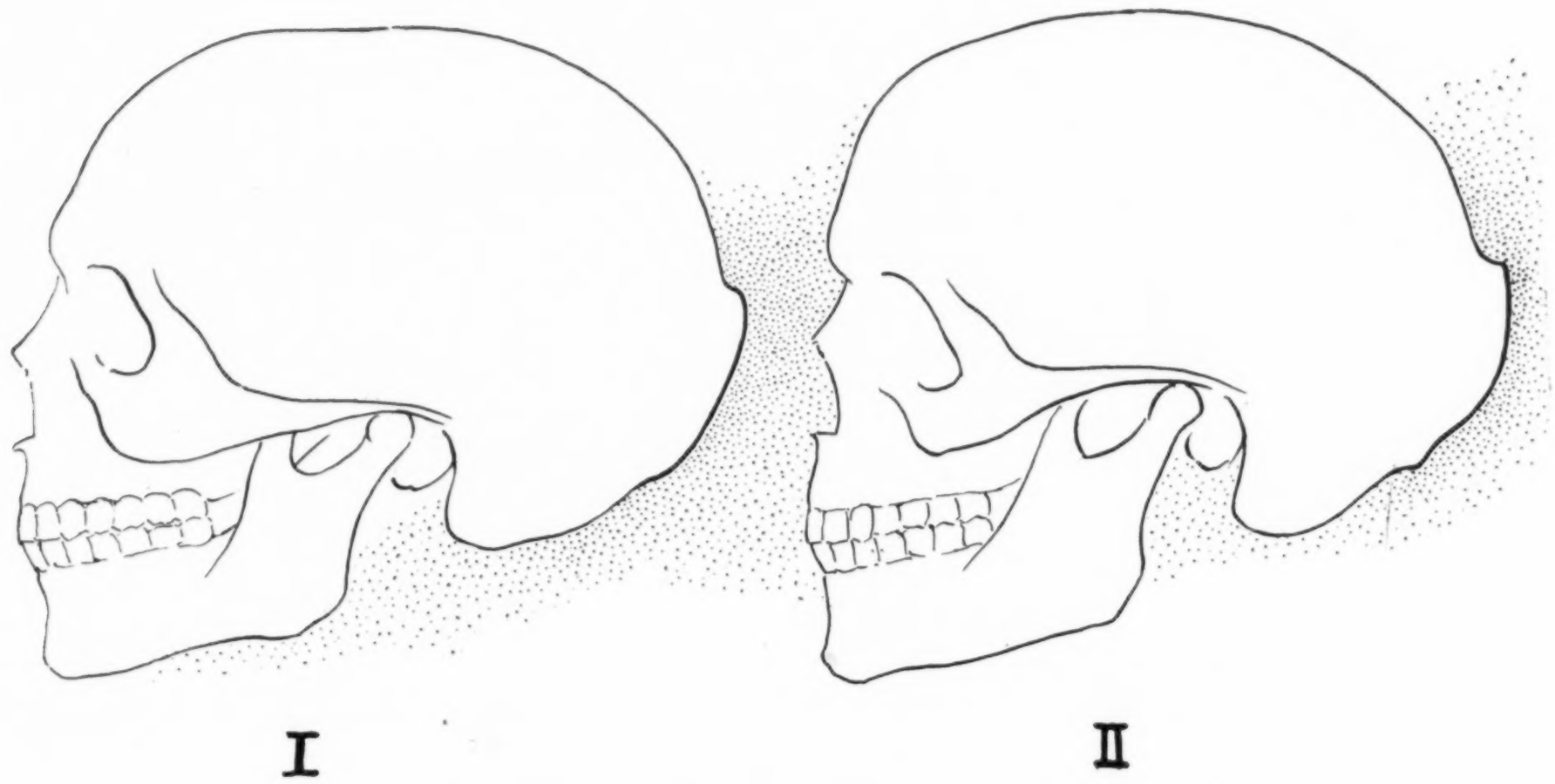
Figure 13

The anomaly is confined chiefly to the bones of skull and to the collar bones (clavicles). The skull bones ossify only slightly at the center, leaving large fontanelles, and the clavicles are represented by a fibrous band. The jaw bones are also somewhat affected.

lacked the clavicular head. The pectoralis major had a few fibres arising from the fibrous band. The clavicular fibres of the deltoid and the trapezius muscles were missing. The subclavius muscle took origin from the superior surface of the costal arch and was inserted on the median margin of the acromion.

The accompanying anomalies to be mentioned in this case were, the cleft of the uvula and the ununited maxillae. Hamilton, 1880, described the disjunctions of the multiple epiphyses associated with cleido-cranial dysostosis. Hultkrantz noted a dislocated humerus and the depression of the sternum. Villaret and Francoz, 1905, pointed out the retarded development of the teeth. A case reported by Langmead, 1916, showed brachydactylism and hydrocephalus. In the summary of sixty cases by Fitzwilliams, 1910, is mentioned the high vaulting of the palate, cleft palate, and poor development of the maxillae. (Chart I, Figure 12).

The family history of this case shows the mother in Generation I to be affected. The medical history indicated one living child, four still-births, periods of gestation unknown, and the seven months foetus which was delivered as a still-birth at the last pregnancy. The living child and the mother show an absence of the clavicles and the presence of patent fontanelles. The



DEPRESSION OF THE OBELION

Figure 14

Showing two degrees of depression at the back of skull on the line of fusion of the occipital bones with the parietal. This character has been traced for four generations in two families (See fig. 12).

dissection and X-ray of the foetus revealed a similar condition.

Depression of the Obelion

Depression of the obelion of the skull is a malformation in the region of the lambda at the line of fusion of the occipital and parietal bones. The depression varies in depth in different individuals and is more noticeable by palpation than by X-ray picture.

The anomaly shows its definite inheritance in a family illustrated in Chart II, in which the affected individuals are designated by the shaded areas. The sibs of the great-grandfather in Generation I were unknown. Of the children in Generation II, eight of the seventeen are living and all but one of those living show the defect. In Generation III eight of the twenty children are affected. The anomaly appears less frequently in the later generations with a decrease from 47% affected in Generation II to 35% in Generation III and 20% in Generation IV.

The degree of the depression was not constant in members of the family. The deep depression, present in the grandfather in Generation I, was transmitted to only one son in Generation II and to that man's youngest son in Generation III. Figure 14 illustrates the skulls of this son and his older brother who had a moderate depression. No. I represents a skull with a moderate depression and No. II a skull with a deep depression, as shown by the X-ray. There seemed to be a slight thickening of the bone at the line of depression, but this was not comparable to the depth as evidenced by palpation.

A similar case has been reported by Stock, 1923, of a family of the same number of individuals as observed here. (Chart III).

Stock did not mention any variation in the depth of the depression found in different members.

Table I shows the distribution of the individuals in the four generations of both families.

Stock's case shows a greater decrease of affected individuals in proportion to the normals from Generation II to Generation III than in the other

case. Generation IV cannot be considered because the affected children were all in one family.

Table I.—Distribution of members in generations

Generation	Normal	Affected	Male	Female
Present Case				
I	5	1	1	0
II	1	7	4	3
III	13	7	4	3
IV	4	1	1	0
Stock's Case				
I	1	1	1	0
II	1	5	3	2
III	23	5	4	1
IV	0	3	2	1

Both families have thirty-nine members. Sixteen were affected in the first case and fourteen in Stock's case. The same number of males were affected in each family, but in Case I there were six females who were affected and only four in the other family.

Since the case reported by Stock is the only one on record, it will be interesting to compare the similarity of distribution of the defect in the two cases.

Table II shows the number of normal and affected children of affected parents in both cases.

Table II.—Proportion of normal and affected children

Affected parent	Affected children	Normal children
Present Case		
4 fathers	10	6
4 mothers	4	8
Stock's Case		
4 fathers	8	11
3 mothers	3	10

Affected parents in these families transmitted the defects to 41.6% of their children. In only one case a normal parent had an affected child and this child had the defect to a slight degree.

The depression of the obelion appeared as a modification of the normal structure in about half the members in two families. It has been traced through four generations affecting 41.6 per cent of the children whose parents were affected in each case. In one branch of the family the defect skipped a generation, appearing again in the only child of normal parents. Except for this one variation the anomaly seemed to be inherited as a dominant Mendelian trait.

Hare-Lip and Cleft Palate

Hare-lip and cleft palate are fissures of variable extent through the maxilla, the long alveoli, the soft tissues in the roof of the mouth. The defect is due to a retarded development during the eighth to tenth week of foetal growth. If the two palatine processes of the maxilla fail to unite with the nasal-frontal processes at the base of the skull, there is a complete cleft through the floor of the nasal cavities and the soft tissues involving the uvula and lips; this is known as a bilateral cleft of the lip and palate. When only one division of the palatine processes reaches the midline to unite with the septum, a unilateral cleft occurs on the other side.

It has been estimated that four out of five unilateral clefts occur on the left. There is no marked prevalence in either sex, according to Berry and Legg, 1912.

Davis, 1924, reported the cases of cleft lip and palate observed in the new-born children at Johns Hopkins Hospital. There was an incidence of .53 per cent affected children; .18 per cent of the negro births being affected and .89 per cent of the white births.

The etiology of hare-lip and cleft palate is not known but many causes have been suggested. Dorsey held the theory that in the foetus the tongue is in position at the base of the skull and nasal septum and if it does not recede early in foetal life it will prevent the descent of the palatine processes and the closure of the maxillae. Brophy, 1923, explains this defect in structure as due to the position of the foetus in utero. He believes there might be a pressure of the tongue and mandible against the alveolar inclined planes thus preventing a closure of the palate. Other causes for a congenital origin of the defect were, faulty metabolism, pathological lesions, lack of sufficient nutrition, inflammation, and trauma.

The possibility of an hereditary cause

has been suggested when the defect can be traced to numerous relatives of the patient.

Hare-lip and cleft palate are often associated with other skeletal defects which appear to be due to faulty development also. Their appearance in an individual who has inherited another malformation would suggest a possibility of an hereditary basis.

Lucas, 1914, regarded the anomaly as an inherited condition but he did not designate a mode of inheritance. He found an absence of the lateral incisor in the parent of a child with a hare-lip and cleft palate and he claimed this peculiarity in the parent foreshadowed the defect in the child.

Berry and Legg, 1912, believed hare-lip and cleft palate were inherited but since the defect appeared in one generation and then was not present again for several generations later they could not explain the mode of inheritance.

Lücker, 1924, however, claimed the defect was inherited as a dominant character and explained any variation in its occurrence by the effect of the hereditary factors which cause a variation among the members of a family. These variations in the dominant mode of inheritance Lücker calls "incomplete dominance." He adds "since in some families hare-lip and cleft palate, or both, occur in some persons and split uvulus in others, these variations show a declining form of the anlage."

Davenport, 1913, suggested that hare-lip and cleft palate act as a dominantly inherited character, but he also noted the frequent appearance of affected children whose parents are normal.

An analysis of the family histories of a group of patients with hare-lip and cleft palate showed 80 per cent of the families had no other case in three or four generations. In those families in which more than one member had been affected the known cases were irregularly distributed. The affected persons were sibs, cousins, or more distantly removed.

The family histories of twenty-five of these patients included 327 members, 11 per cent of whom had deformed lips and palates. The 167 parents in these families had 211 children, 27 per cent of whom bore the anomaly.

The variations of the defect as found among the different members were distributed as follows:

50 per cent were left cleft palates
9 per cent were left cleft palates and hare-lips
13 per cent were bilateral cleft lips and palates
27 per cent were left hare-lips
1 per cent were right hare-lips

Eighty-six per cent of the cases were on the left.

The sex ratio of the affected individuals in these families was 1:1.4, being slightly more frequent in males.

The associated anomalies observed among these cases were polydactylism, syndactylism, hydrocephalus, microcephalus, spina bifida, club-feet and dislocations. It is interesting to note that of these associated anomalies polydactylism, syndactylism, club-feet, and dislocations of some kinds are hereditary in some cases.

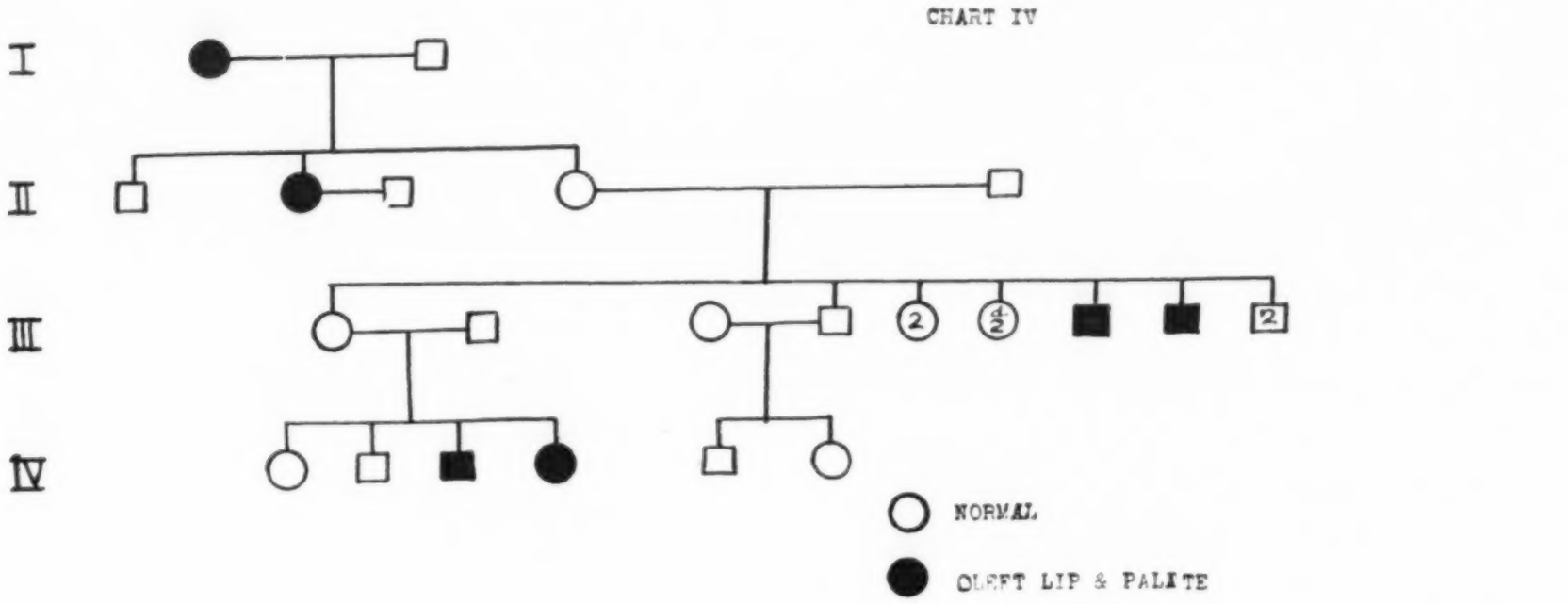
The family history charts show the relationship of the affected individuals in several cases. Table III shows the distribution of affected individuals in three generations as noted by the family history.

Table III.—Distribution of members in generations

Generation I	99 normal	1 affected—	1.0%
Generation II	116 normal	2 affected—	1.6%
Generation III	67 normal	32 affected—	31.3%

Charts IV and VI illustrate families in which the anomaly occurs in individuals of scattered branches of the family. The direct inheritance shown in Chart V is less commonly observed but the irregularities of the anomaly as found here are quite typical of other cases.

An analysis of the family histories of patients reported here with hare-lip and cleft palate definitely indicated the defect to be of congenital origin in about 80 per cent of the cases. In the remaining cases no other individual was known to have been affected in the three or four previous generations.



INHERITANCE OF HARE LIP AND CLEFT PALATE

Figure 15

In many cases of cleft palate no other instances are known in the ancestry, but about twenty per cent of these anomalies seem to have an hereditary origin. Frequently the affliction skips a generation.

The families of the smaller group of cases are well represented by the charts. Few cases showed a direct inheritance. In the other cases the affected individuals of a family were distributed into various branches of the family.

The method of occurrence cannot be explained on the basis of simple Mendelian inheritance. Moreover, the fact that the anomaly appears in only one individual of a family does not preclude the interpretation of congenital origin. Therefore, the origin of hare-lip and cleft palate cannot be explained as congenital or hereditary, from the data at hand, although both causes seemed to be represented.

Other Cranial Anomalies

Studies of the inheritance of other cranial anomalies such as defects of the teeth and ears have not been completed for this paper, but a few cases which have been reported recently show an hereditary influence which is of interest here.

The two cases of incomplete dentition which were selected show variations of the defect. In Case I the patient was a boy of twelve years who had only twenty-six teeth. Both upper canines and lower first and third molars were missing. A younger sister showed an absence of both upper canines, second premolars, and third molars. The left incisor and third molar, right second premolar, and third molar were lacking in the lower jaw. An older sister lacked both upper canines. The canine, first premolar and first and second molars on the right side as well as the left first premolar anad both incisors, were absent in the lower jaw. X-rays of the jaws of these children showed a complete absence of the teeth indicated as missing. The condition of the mother was uncertain.

In Case II the father and two daughters showed an absence of the upper canines. Two sons and a daughter had normal dentition.

Another peculiarity was observed in a small boy whose teeth were soft and appeared transparent. His mother, sister, and brother had a similar condition.

Ossification of the cochlea which causes partial or complete deafness has been reported by Shambaugh, 1925, as of hereditary nature. His survey in the Chicago schools found 50 per cent of the deafness to be of congenital origin; 57.9 per cent of these children being totally deaf. Forty cases reported a family history of deafness, eleven of whom claimed their parents were cousins. Fifty-eight children had from one to four sibs who were deaf.

The mode of inheritance of these anomalies cannot be estimated from so few cases but they suggest a probable hereditary origin.

Anomalies of the Trunk

Anomalies of the skeletal structure of the trunk are not rare, but, the records of such malformations are scarce. Bertolotti, 1921, discussed the anomalies of the vertebrae which he claimed can be present along the whole course of the spine. Supernumerary ribs occur in the cervical and lumbar regions but are more frequently attached to the lumbar vertebrae. Ossification of the muscles, fusions of the vertebrae, dislocations, and other variations are frequent.

Congenital Dislocation of the Hips

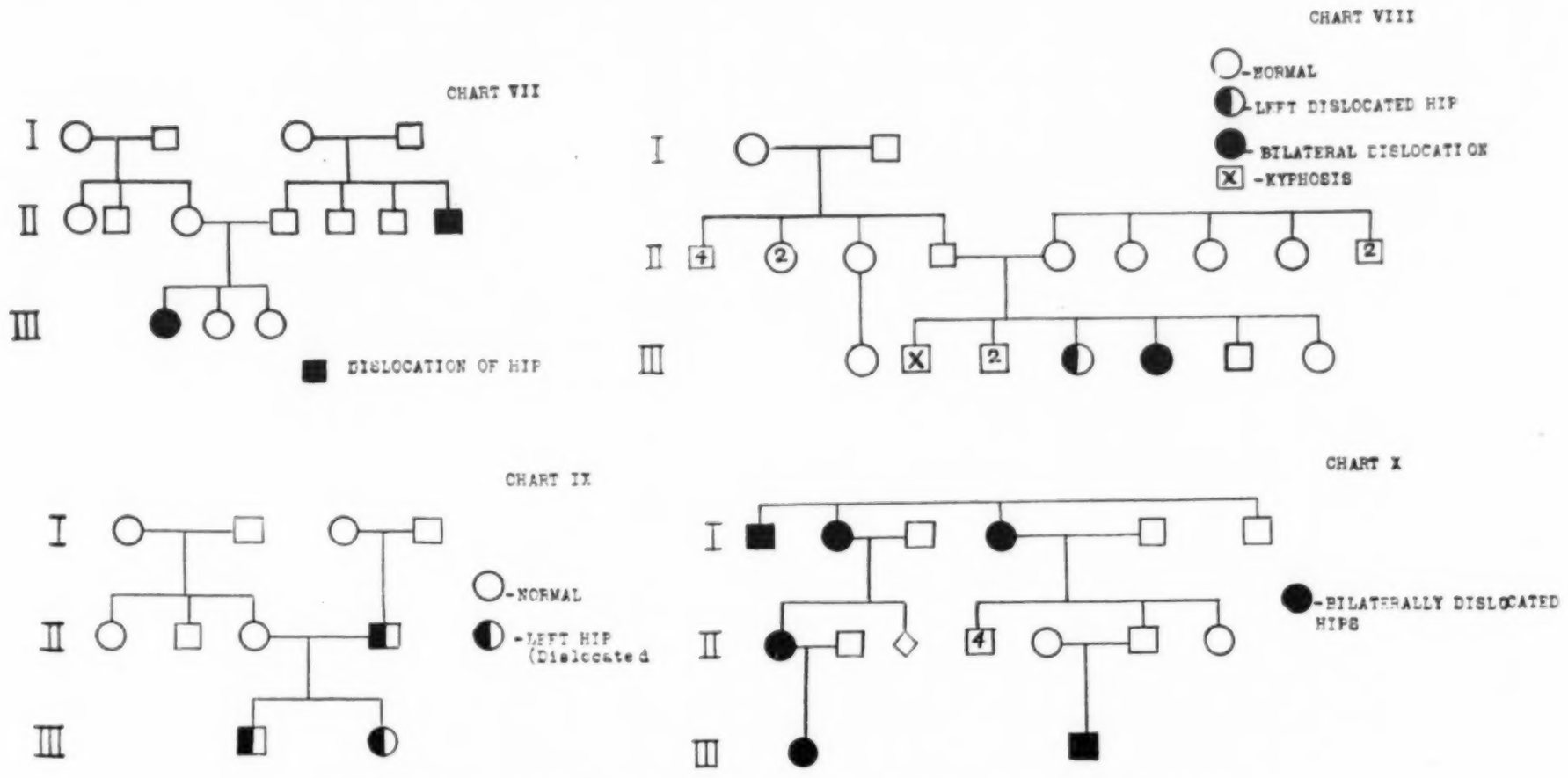
Congenital dislocation of the hip is an upward and backward displacement of the head of the femur which is connected with the acetabulum by a stretched capsule. The condition is present at birth but is seldom observed until the child begins to walk. During growth there is an abnormal development of the head and neck of the femur since there is no apposition with the acetabulum. (Lovett and Jones, 1923.)

The acetabulum is shallow and triangular in shape and the base is filled with fat or fibrous tissue. The head of the femur, therefore, lies above and behind the acetabulum; the upper epiphysis does not ossify and has an abnormal relation to the long axis of the neck. The capsule acts as a suspensory ligment, thickened and stretched, so that the head of the femur rests on the ilium and obliterates the acetabulum. Congenital dislocation of the femur is probably due to the shallowness of the acetabulum. and therefore, the inheritance of the defect would not be the inheritance of the dislocation but the inheritance of the shallow acetabulum so the dislocation may occur in utero or when the child begins to walk. On the other hand the dislocation may not occur until later in life when the necessary pressure or accident may cause the head of the femur to slip from the shallow acetubulum. Since the defect of the hip may not be noticed, unless by the examination by X-ray, the hereditary cases are not easily observed and recorded.

Records of one hundred families of patients with dislocations of the hip showed 1,132 members; of these, 120 or 10.4 per cent had dislocated hips. The diagnoses of these patients placed them in three groups: those with a right hip dislocation, those with left dislocation and those with bilateral dislocations. There was an equal distribution of cases in each of the three groups. Sixty-four per cent of the cases of bilateral dislocations occurred in females.

The sex ratio was 3:1 showing a greater number of females to be affected. This higher incidence among the females may be explained by the width of the pelvis and the angle of the femurs which is greater than in the males and is more favorable to dislocation.

The influence of heredity in these cases was determined by grouping them according to generations.



INHERITANCE OF DISLOCATION OF THE HIP

Figure 16

Congenital dislocation of the hip is due to the abnormal shallowness of the acetabulum, the cup in which the head of the femur rests. Thus congenital dislocation of the hip appears to be due in twelve per cent of cases to hereditary shallowness of the acetabulum.

Table IV.—Distribution of members in generations

Generation	*Normal*	*Affected*
I	391	4— 1.00%
II	409	13— 3.08%
III	209	106—33.60%

There were 597 normal parents, who had 116 or 15.8 per cent affected children and 619 normal children. The ten parents who were affected had 9 or 23.7 per cent affected children and 29 normal children.

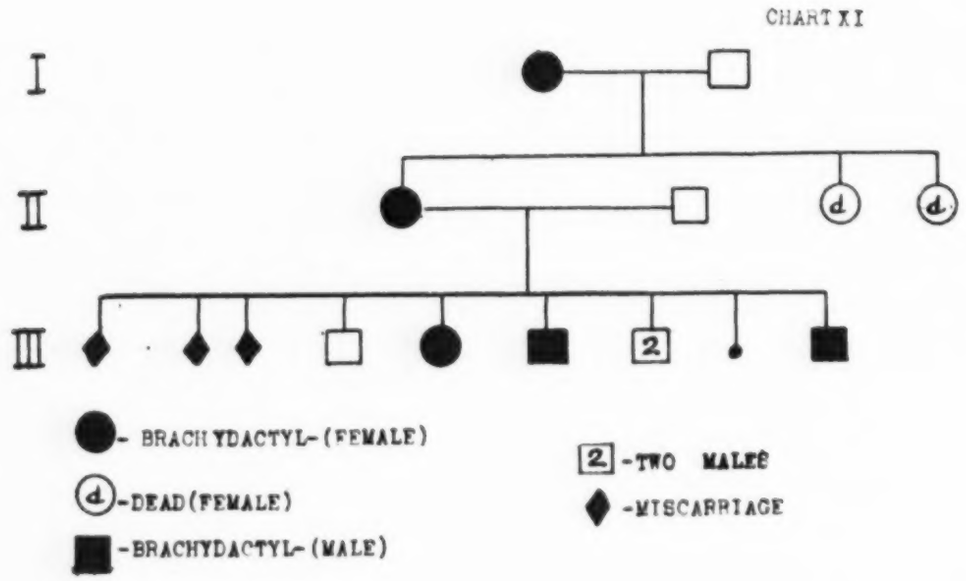
The following pedigrees of families in which one or more members had dislocated hips, may be taken to illustrate the inheritance and distribution of the defect among the members. (Figure 16).

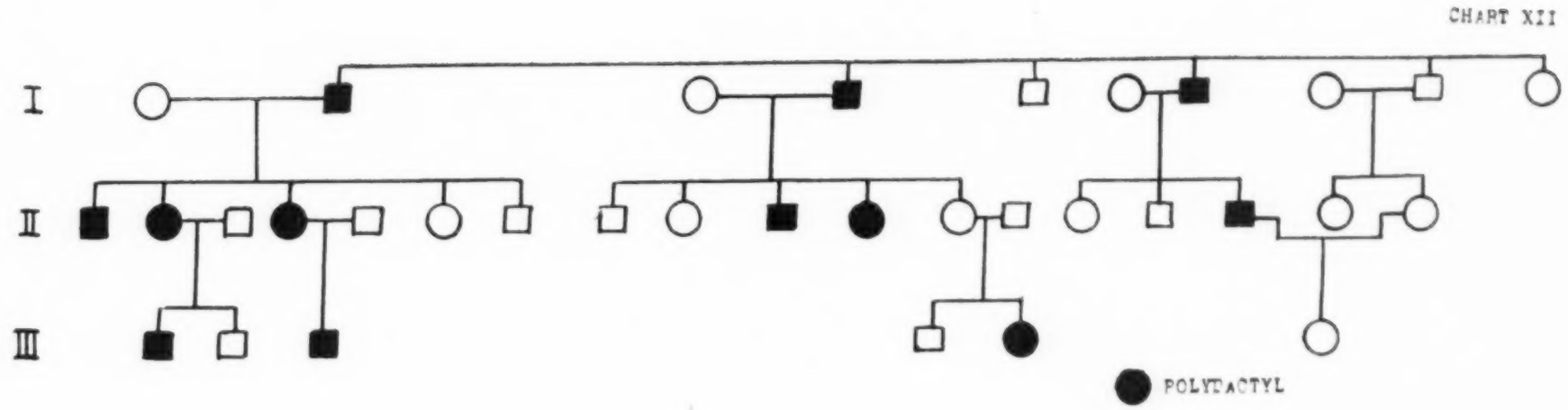
The analysis of the cases studied showed that 88 patients had no affected relatives, but that the other twelve patients had from one to five relatives who bore the defect. Four patients had affected brothers and nine had affected sisters. At least 12 per cent of the cases might be interpreted as due to the inheritance of a recessive character.

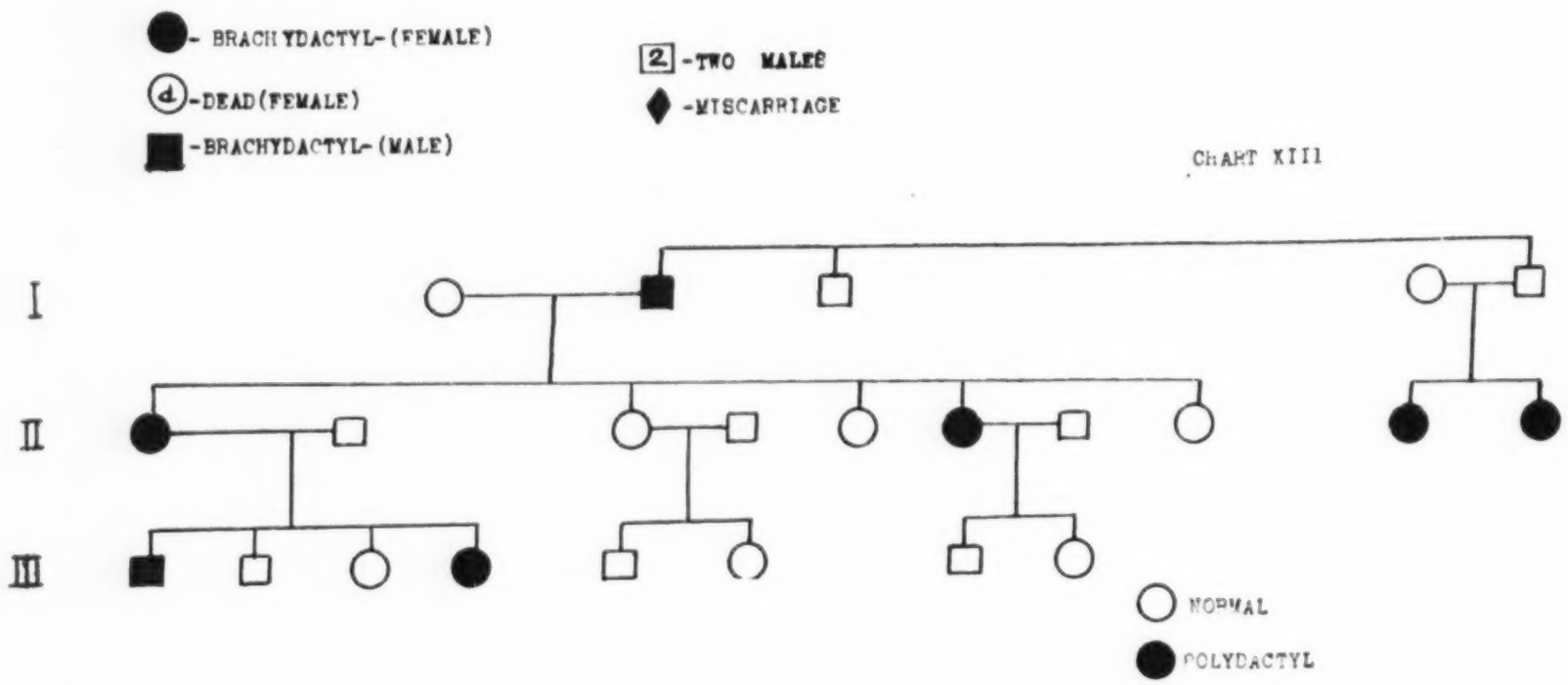
The recognition of the hereditary character of congenital dislocation of the hip was first reported by Zwinger, 1710, who observed the condition in a mother and three of her six children. Bilateral dislocations were present in all of these persons. Vital, 1834, reported another family in which the father had bilaterally dislocated hips; the mother had a left dislocated hip; and the son had bilaterally dislocated hips. Krönlein, 1882, treated a woman and her seven grandchildren for dislocated hips. Thurman, 1893, spoke of taking care of two children whose maternal grandfather also had dislocated hips. Vogel, 1905, reported 30 per cent of his 200 cases were from families with an hereditary tendency to the anomaly. Hayashi and Matsuoka, 1913, made particular note of all cases with a family history of the defect. Of their 1,096 cases, 14.7 per cent were due to heredity and 3.4 per cent showed a familial tendency.

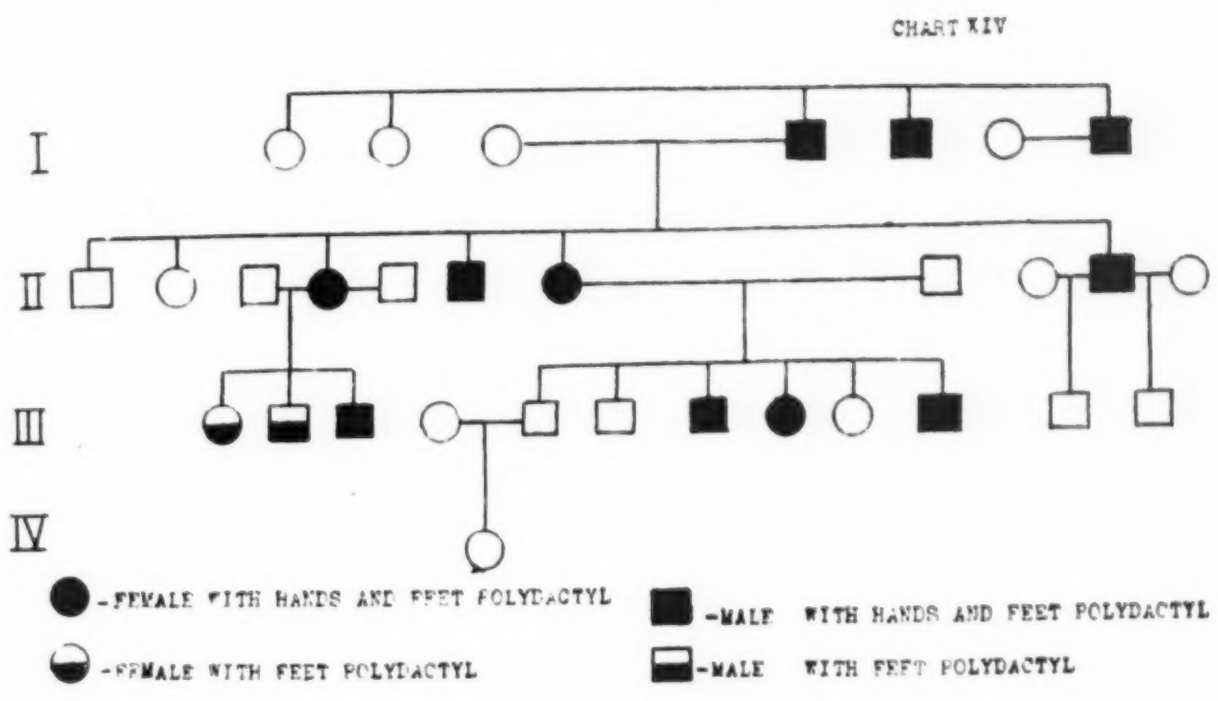
A study of 100 families of patients with a supposedly "congenitally" dislocated hip showed that 10.4 per cent of the members were affected. Eighty-eight per cent of the cases showed a tendency to be inherited since 40 per cent of the parents and 23.7 per cent of their children were affected.

In those cases where a tendency to-









INHERITANCE OF SHORT FINGERS AND EXTRA DIGITS

Figure 17

ward inheritance was indicated (12 per cent of the cases) the anomaly appears to be transmitted as a dominant in some families and as a recessive in others. This group of cases is, however, too small to use for any statistical conclusions concerning the definite mode of inheritance, but the family records and incidence of affected individuals indicates that there is a tendency towards inheritance, possibly in the manner of an incomplete dominant.

Since at least 12 per cent of the cases seemed to be inherited, the term "congenital" as used here can not apply to those cases.

Anomalies of the Extremities

Congenital anomalies of the extremities are probably the most common skeletal deformities. Malformations of these regions reported to be hereditary are: fragilitas osseum, cartilagenous exostosis, club feet, syndactylism, and polydactylism. Radio-ulnar synostosis and absence of the long bones have also been reported to have an hereditary tendency. There are many records of individual cases of these defects but there are no group studies from which to determine the mode of their inheritance.

Fragile bones, due to a weakness and brittleness of the long bones, shows a marked hereditary tendency. Conrad and Davenport, 1915, concluded from their studies that the factor which determines the imperfect development of the bones is a dominant. They found that 55.3 per cent of the children of affected parents were also affected.

Brachydactylism, or short digits, has been noted to be inherited as a dominant character. (Davenport, 1913, Thomson, 1920, Schinz, 1924). The pathology of the condition has several interpretations, but the anomaly present in the family illustrated in Chart XI was due to short phalanges. Figure 18 shows the hands of the mother in Generation II. Chart XI. This woman was only 55 inches tall which suggests that the long bones might have been affected. The condition as it appeared in this family seems to be inherited as a dominant character. (Figure 18).

Polydactylism or supernumerary digits is a common anomaly especially in the negro race. In collecting family histories of this malformation is was noted that three variations of the condition occurred; therefore, the cases studied were classified as Types I, II, and III.

Polydactylism—Type I

The extra digit, peculiar to Type I, is illustrated in Plate IV. The small fleshy mass had a true finger nail and was attached by a mere pedicle to the lateral margin of the fifth digit in the rigion of the first phalangeal joint. Danforth, 1919, reported the findings from a dissection of this type of an extra digit. Muscular tissue with a cartilagenous core made up the fleshy mass, into which extended the tendon slips from the abductor digiti quinti and flexor quinti brevis muscles. The artery and nerve of the fifth digit were bifurcated, sending branches into the extra digit.

Among the families in which this type of polydactylism occurred 21.3 per cent of the members were affected. There was no marked prevalence in either sex. 44.6 per cent of the children of affected parents had the anomaly, and of the children of normal parents 37.5 per cent were affected.

The influence of heredity may be noted in Table V by the distribution of the members in the generations. The number of affected individuals increase in succeeding generations in proportion to the normals.

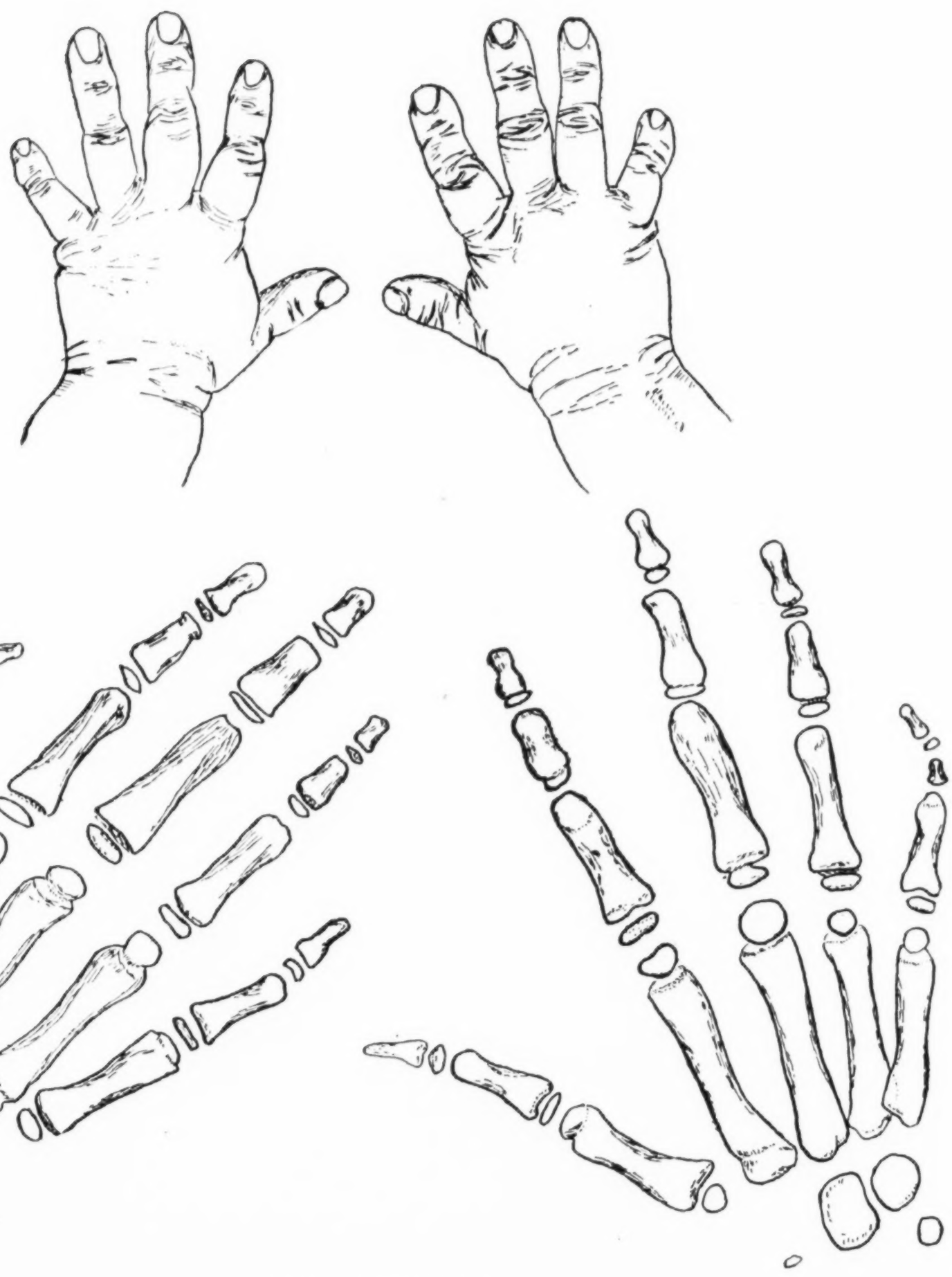
Table V.—Distribution of members in generations

Generation I	24 normal	4 affected—14.0%
Generation II	63 normal	11 affected—15.0%
Generation III	54 normal	21 affected—28.0%
Generation IV	7 normal	4 affected—36.3%

Polydactylism—Type II

Supernumerary digits appearing as a complete duplication of the fifth digit were grouped as Type II. The extra digit had three complete pha-

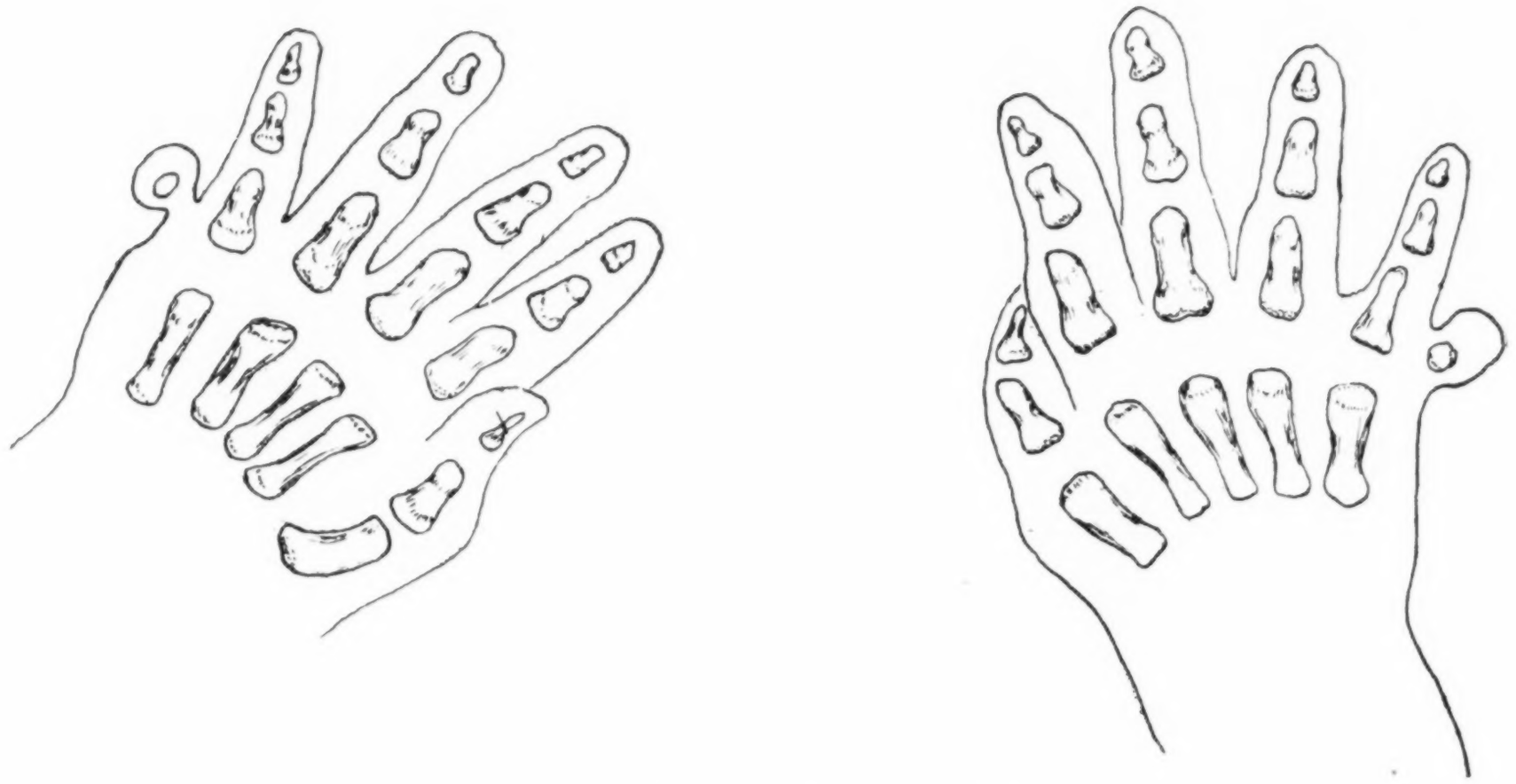
PLATE III



SHORT FINGERS

Figure 18

External and X-ray views of short fingered individual in generation II in family shown in Chart XI. This woman was only 55 inches tall, which suggestes that the long bones were also affected.



A VESTIGIAL EXTRA FINGER

Figure 19

This form of polydactylism is designated Type I. The small fleshy mass at the base of the fifth finger has a true nail.

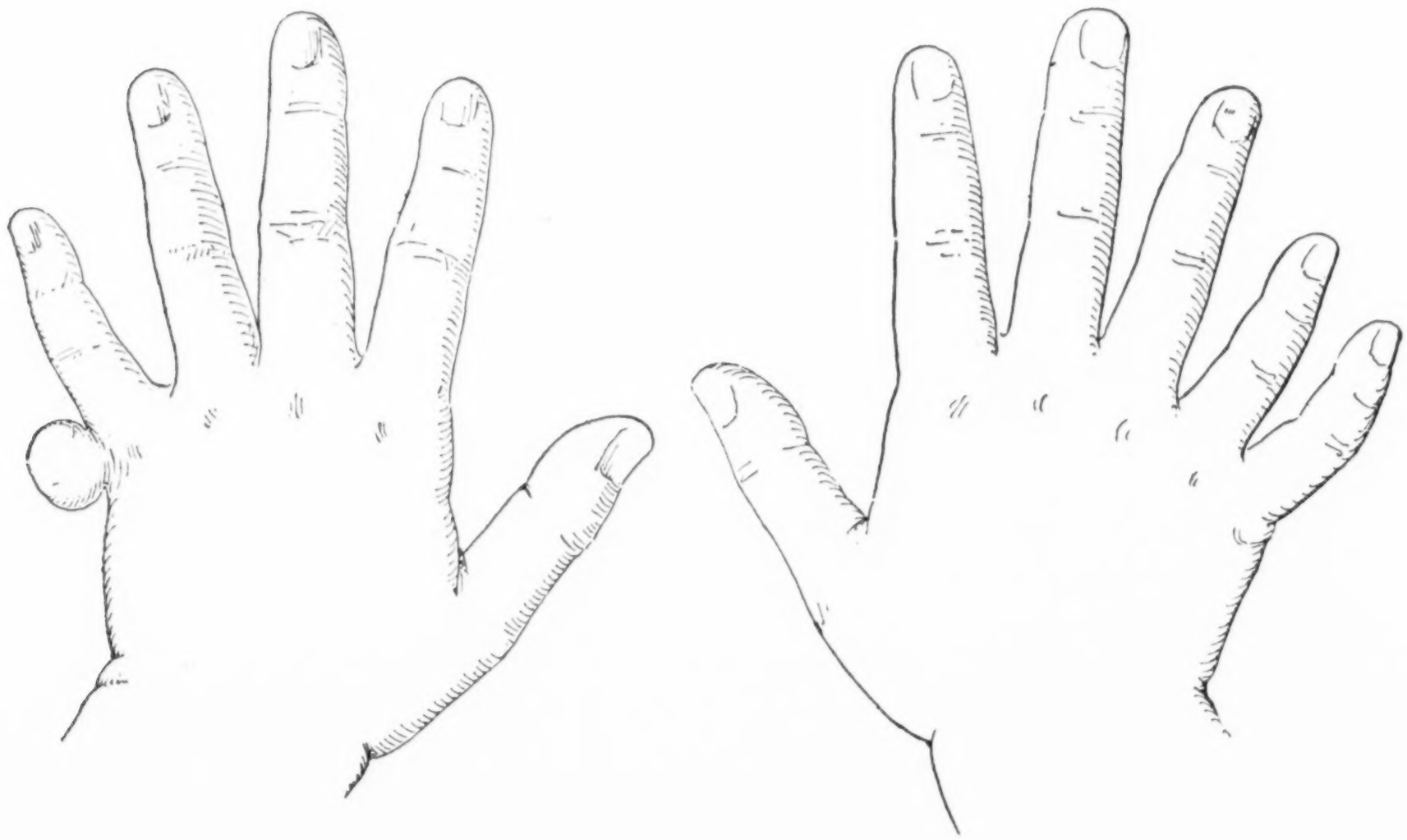
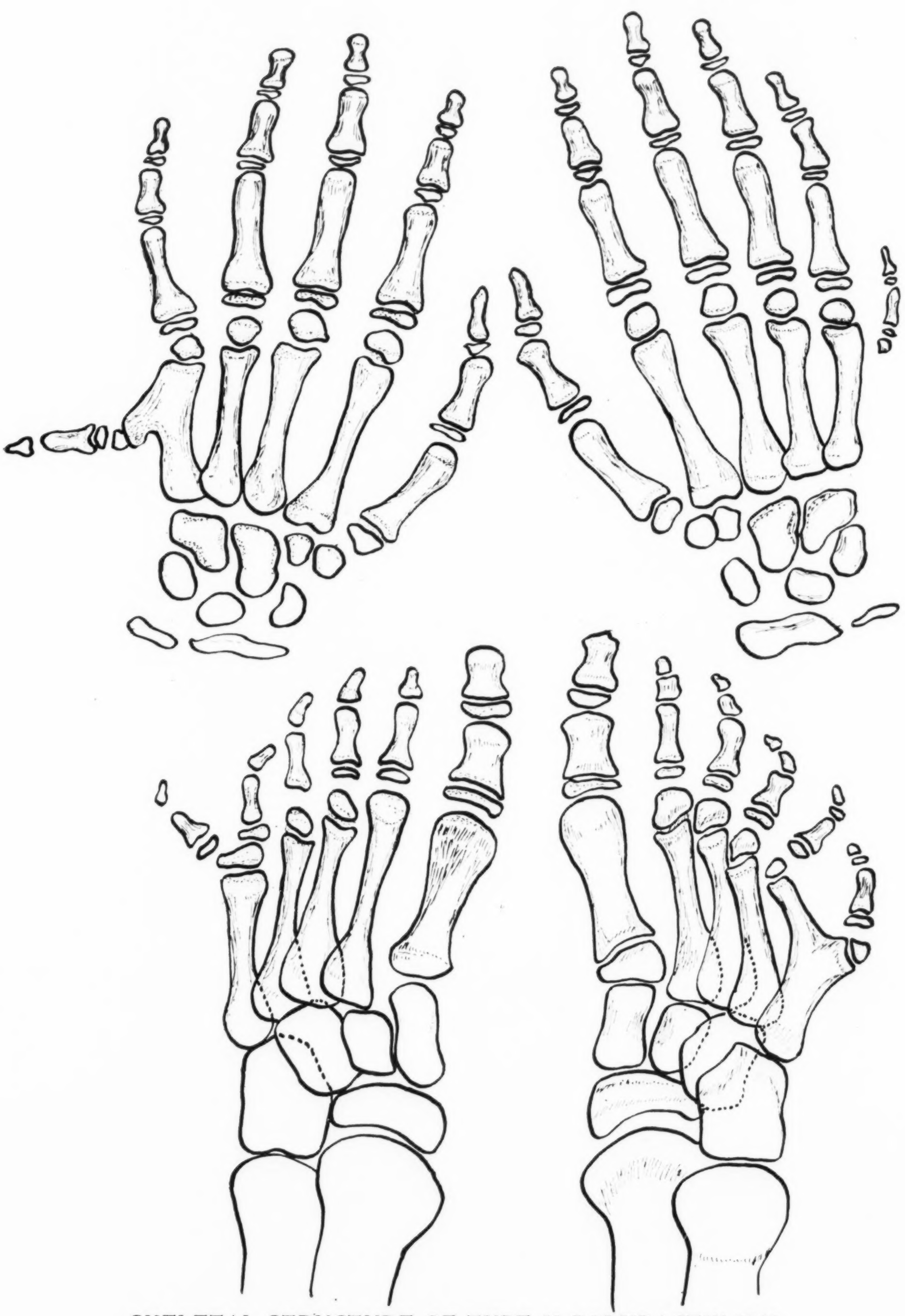


Figure 20

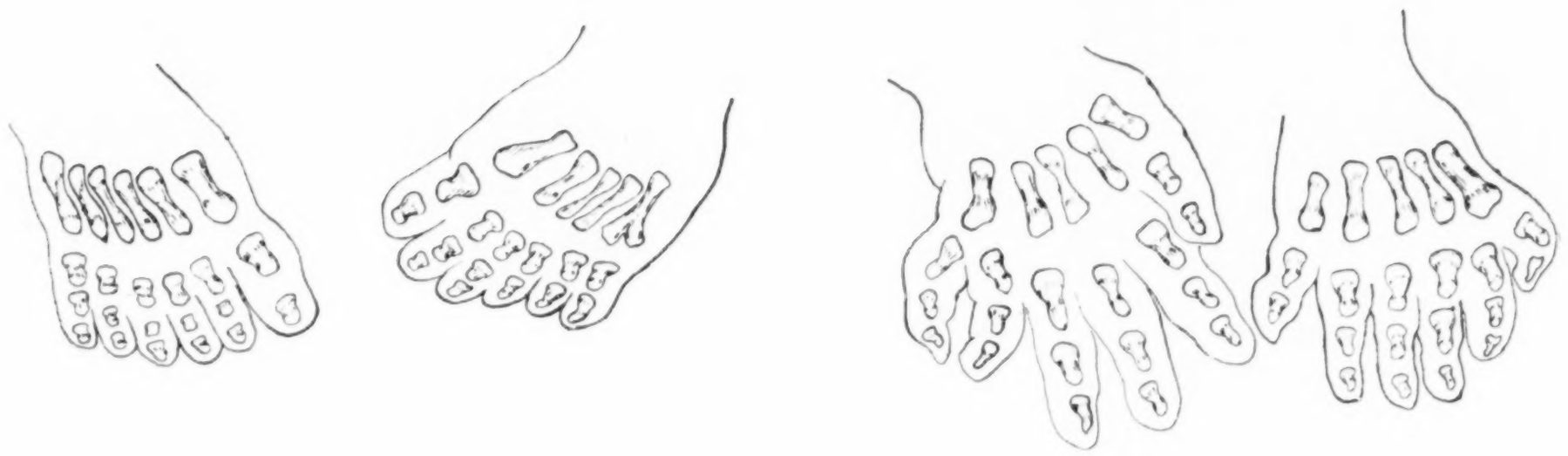
At left—exterior view of type shown in Figure 19. At right—complete reduplication of little fingers. This form of polydactylism is designated type II in the text. This individual had no other polydactyl relatives (see Chart XVIII).



SKELETAL STRUCTURE OF TYPE II POLYDACTYLISM

Figure 21

The left hand and the right foot had a branch on metacarpal and metatarsal to accommodate the extra digit. On the other side the readjustments were not so extensive.



DOUBLE THUMBS—AN INHERITED ABNORMALITY

Figure 22

In this rare form of extra fingers a full sized extra thumb and big toe are found. An external view of such a hand is shown at the right, below.

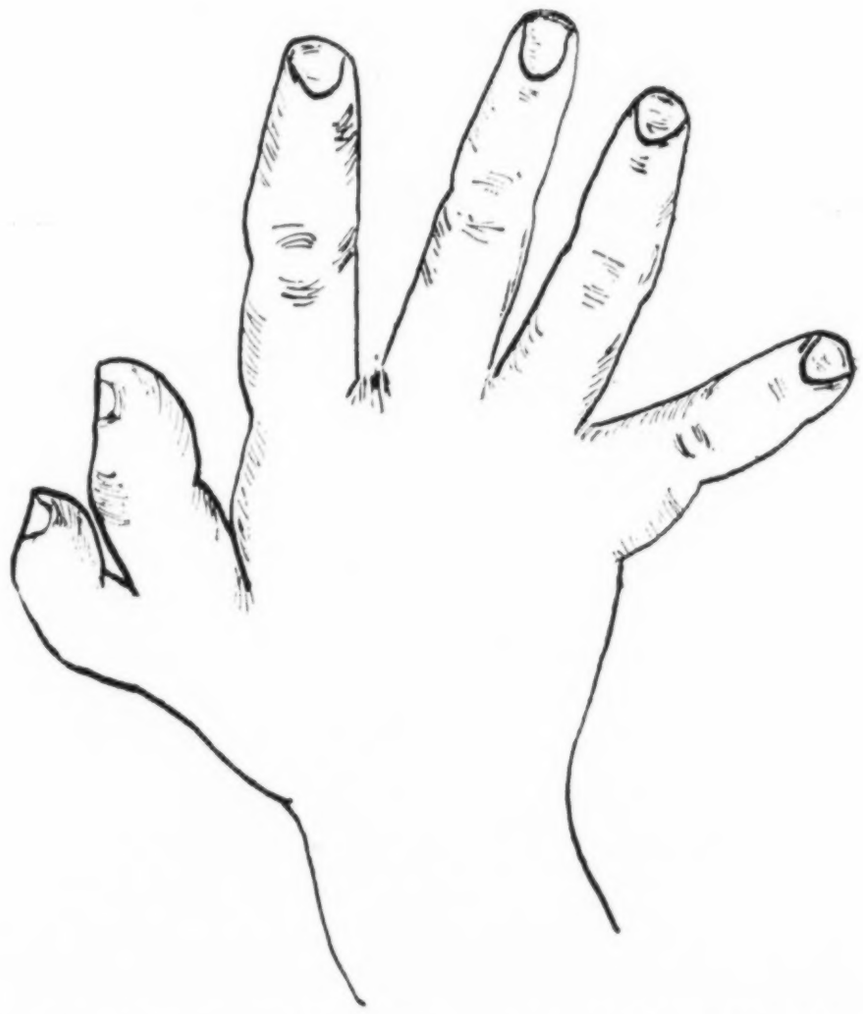
langes but no metacarpal, and articulated with the enlarged or bifurcated fifth metacarpal. This digital anomaly occurred simultaneously on both hands, both feet, or even on hands and feet. (Figure 20).

The X-rays illustrate variations of the metacarpal and metatarsal to accommodate the articulation of the extra digit. The fifth metacarpal on the left hand and the fifth metatarsal on the right foot were abnormally large at the distal extremity and a bony process projected from the lateral side. This bony process was directed somewhat proximad to form an articulation for the extra digit.

The family history of this case is presented in Chart XIV. The abnormality was inherited as a dominant character with variations occurring in only two individuals, those being polydactyl on feet only.

The family histories of Type II showed that 17 per cent of the members were affected; 42 per cent of the children of affected parents were affected. Also, 30 per cent of the children of normal parents were affected. This occurrence of the defect suggests a dominant character with slight modifications from the direct inheritance.

The distribution of indivduals with polydactylism of Type II is indicated in Table VI.



DOUBLE THUMBS—AN INHERITED ABNORMALITY

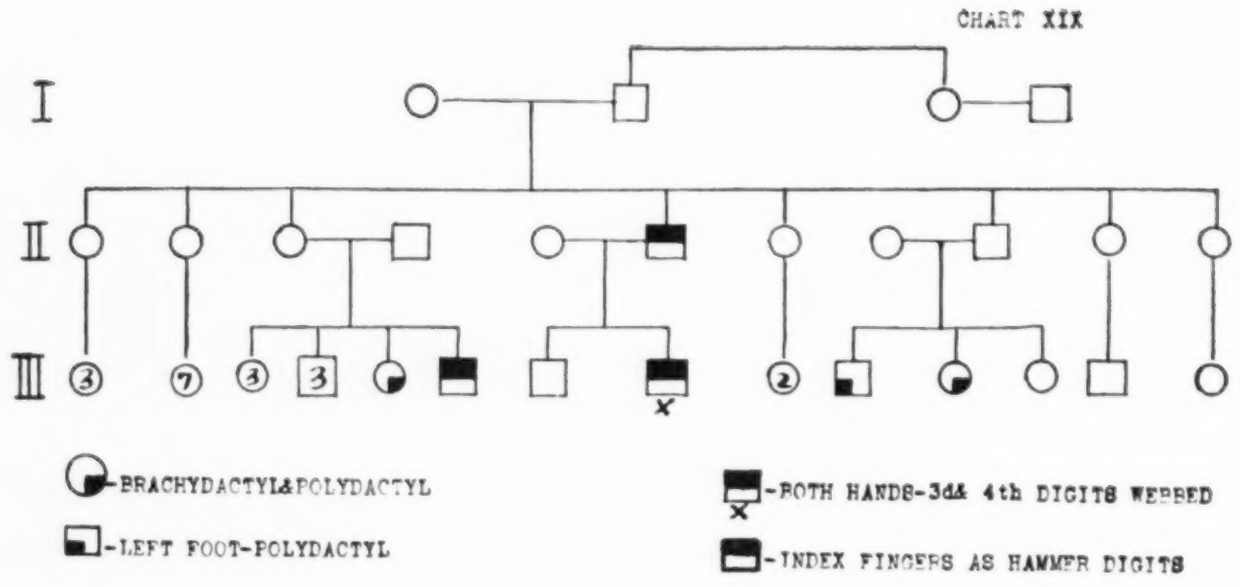
Figure 23

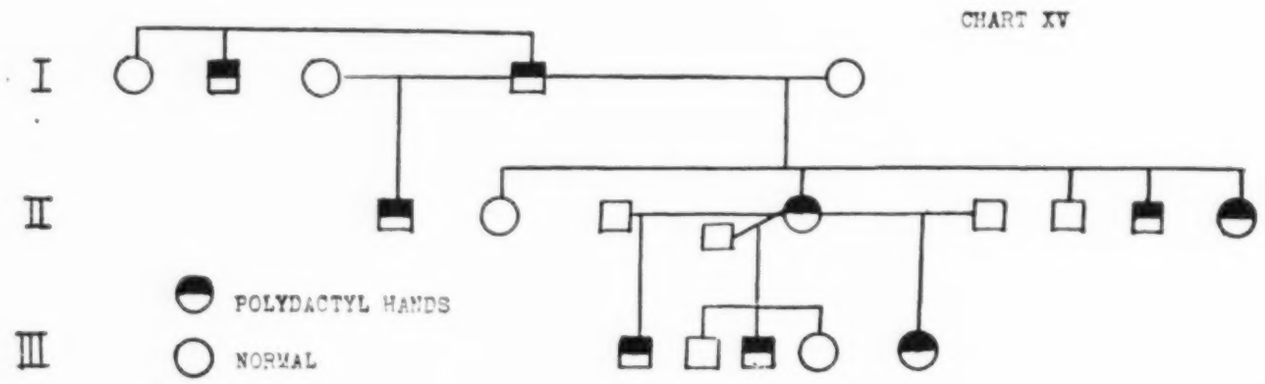
In this rare form of extra fingers a full sized extra thumb is found.

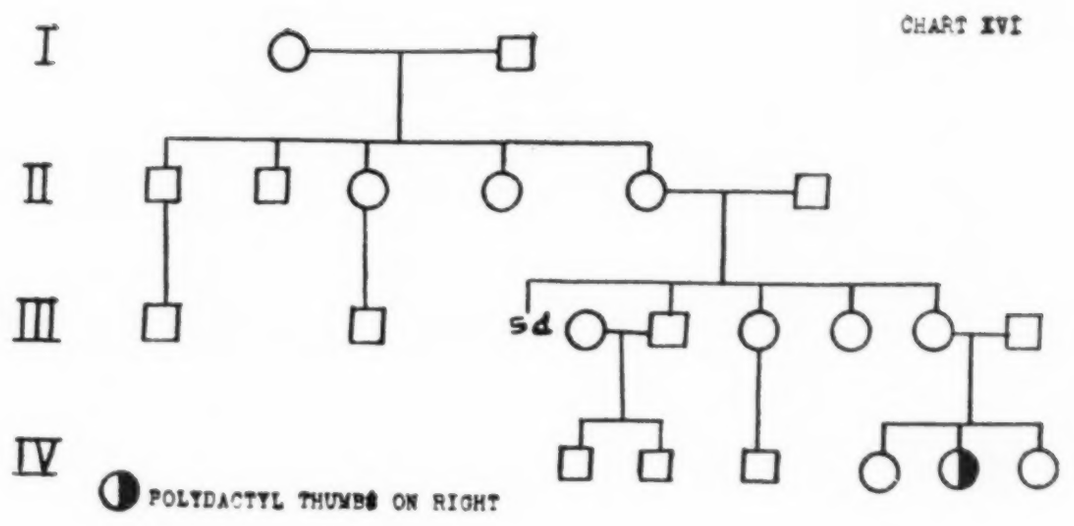
Table VI.—Distribution of normal and affected persons

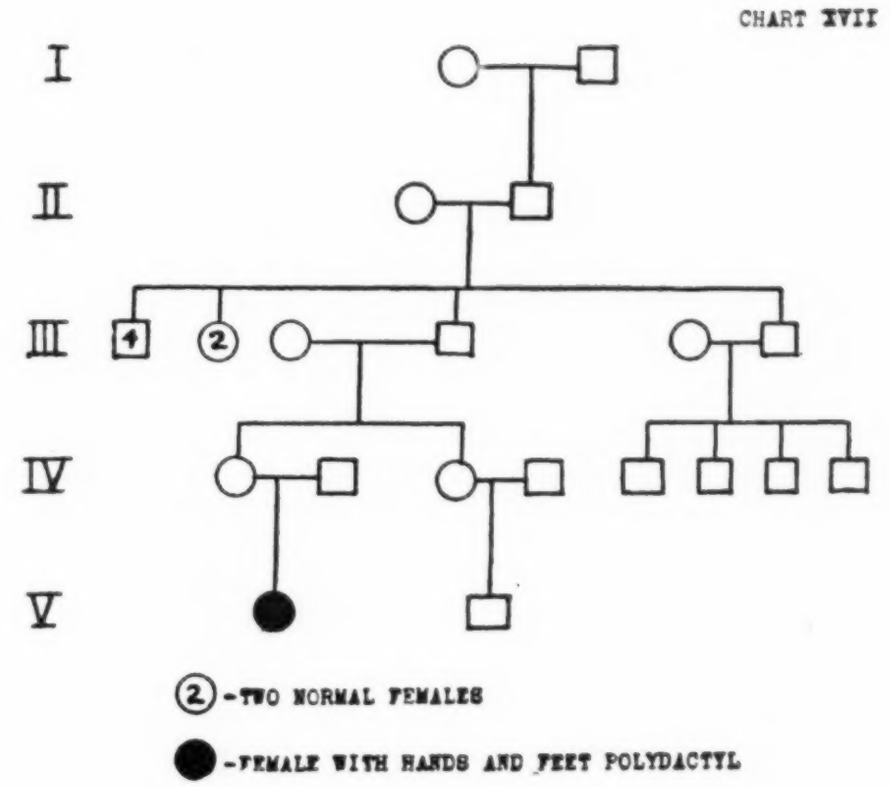
Generation I	22 normal	8 affected—27%
Generation II	63 normal	13 affected—17%
Generation III	107 normal	27 affected—20%
Generation IV	24 normal	8 affected— 8%

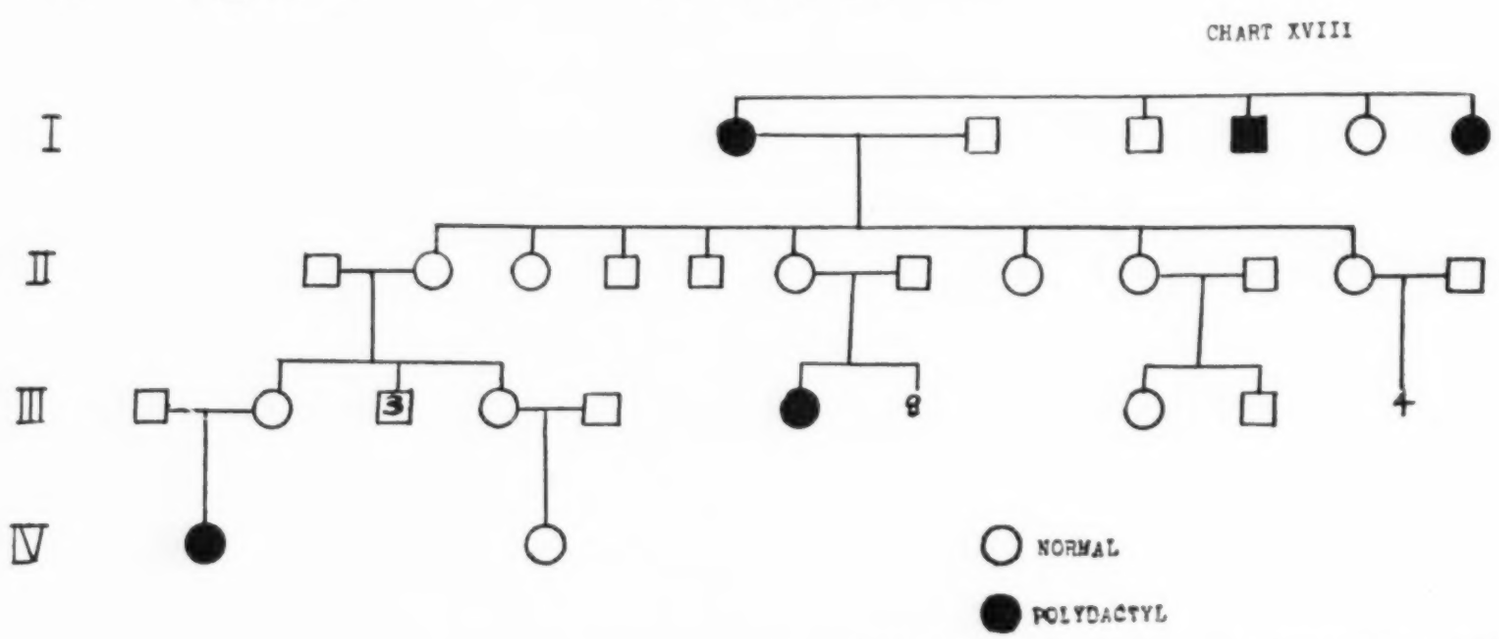
Except for the high percentage of affected members in Generation I there was a gradual increase of affected individuals in proportion to the normals in successive generations.











INHERITANCE OF EXTRA DIGITS

Figure 24

In some families the extra digits are inherited and in other instances the peculiarity seems to be of congenital origin as in Chart XVII, where the child with type II polydactylism comes from a normal family.

Polydactylism—Type III

Polydactylism of Type III is illustrated in Figure 23. The anomaly in this case was present as a duplication of the pollex on the right hand. The similiarity between the two digits made it impossible to determine which was the true pollex. This form of polydactylism is quite rare. (Prentise, 1903). Chart XVI represents the family of this case.

The most common forms of polydactylism occur as Type I or Type II, which are inherited as dominant Mendelian characters. They are not always inherited as clear cut forms by all members of the family. Chart XVII illustrates a family in which both types of the anomaly were represented. Plate IX shows the hands of one member of the family who had both types of extra digits. A more complicated inheritance of anomalies occurred in the family shown in Chart XIX. The affected person in Generation II had hammer fingers of the index digit on both hands. This man's son in Generation III had hammer fingers of the index and webbing of the third and fourth fingers of both hands. Three cousins also in Generation III were polydactyl and brachydactyl on one hand. Another cousin had hammer fingers.

Polydactyl as Type I and II is inherited as a dominant Mendelian character, but Type III appears as a congenital deformity.

A distribution of the affected members in families in which polydaclylism of Type I and Type II occurs may be compared in Table VII.

Table VII.—Affected members in Type I or II Polydactylism

Type I		*Type II*
21.3%	members affected	17.0%
44.6%	affected children affected parents	42.0%
37.5%	affected children, normal parents	30.0%

Polydactylism of Type I, or the rudimentary form, affected a slightly greater proportion of the members than did Type II.

Polydactylism has been observed since early historic times, and frequent case reports have been recorded, but the collective studies of the condition have dealt chiefly with the origin of the defect rather than with the mode of its inheritance. Darwin, 1876, Bardeleben, 1885, and Gegenbaur, 1888, have attempted to explain the presence of the anomaly on the basis of the theory of reversion or duplication, but the question of its origin will not be considered here.

The inheritance of the condition has been reported by Davenport, 1911, to behave as a dominant, although the mode may vary and the defect may be transmitted by a normal parent. Wilson, 1896, reported five cases of polydactylism in which the anomaly had been inherited for several generations. His conclusion to this study of the five cases was that "the abnormalities are generally constant in position but variable in degree."

Bernard, 1916, reported the variations of polydactylism to be more prominent than the intensity of its inheritance. As a dominant character, it would be expected that about half of the children of affected parents would be affected. This was true in the case of Type I and Type II in which the group of families showed respectively 44.6 per cent and 42 per cent of the offspring affected. The presence of 30 per cent to 37.5 per cent affected children of normal parents emphasizes the variation of the dominant inheritance.

Polydactylism, either as a duplicated or rudimentary digit, has a strong tendency to be inherited. In the cases being reported the affected parents transmitted the defect to 42-44.6 per cent of their children, but, on the other hand, cases were found where normal parents transmitted the defect to 30-37 per cent of their children. This indicates that the anomaly is not inherited as a pure dominant character in all cases but may appear to be an incomplete or suppressed dominant. Some cases have been observed, however, which might be interpreted as

being of congenital origin, there being no other affected individuals in four or five generations of the family.

The variation in the mode of inheritance and irregularity in appearance of these various anomalies in the human may be explained by the Mendelian mode of segregation. The appearance of each character is determined by the segregation of its factors so that any faulty distribution might result in an incomplete inheritance, abscence of the character for a generation or more, or variations in intensity of certain characters.

Mendelism supposedly segregates the dominants and recessives but the influence of external stimuli or the presence of other factors which cause an interference within the combination of factors may be the cause for faulty segregation. The incomplete dominance which results seems to explain some of the defects considered here, although the number of cases in each group was too small to act as a basis for the determination of the mode of inheritance of these anomalies. The variations in human breeding result in the combining of so many traits that the estimation of the action of any one must be based on an extensive amount of data.

The Future of the White Races

ENVIRONMENT AND RACE: A study of the evolution, migration, settlement and status of the races of man, *by* GRIFFITH TAYLOR, pp. 354. Price $6.50. Oxford University Press, American Branch, New York, 1927.

THE first and largest section (pp. 12-235) of the work is an elaboration of the author's well-known "Migration-zone theory of race evolution" put forth earlier in the *Geographical Review*. The best that one can say of this highly incautious interpretation of facts, of facts that are only half so, and of facts that are not so at all, is: It is magnificent, but it is not science. Some of the numberless guesses and assumptions will probably turn out to be true, but it is doubtful if the cause of anthropology or of any other science is served by such ingenious romancing.

The second section (pp. 237-95) is a study of the actual and potential resources of the Australian continent as a dwelling-place for the white man, with emphasis on the limitations placed by climatic conditions. The author here sticks much more closely to his facts and is more at home.

The third and last section (pp. 297-341), largely an adaptation of an earlier paper in "Future White Settlement" is "an attempt to forecast the distribution of man a century or two hence," particularly of the white man, by deductions based upon the facts of temperature, rainfall, coal resources, and elevation above sea level. Some of the more important conclusions arrived at are: the centre of the white races must move to the lands discovered since pre-Columbian days; the future white world population of European ancestry will reach 1,347,000,000, of whom 513,000,000 will be in the United States; the useful lands of the world will be fully saturated within two or three hundred years. The conclusions are put forward as "somewhat speculative."

The work contains more than a hundred maps, graphs, and tables; many very valuable, many very misleading, all very interesting.

John M. Cooper.